HYDRO POWER AND ENERGY PLANNING PROJECT (HPEP)

# COST-BENEFIT ANALYSIS MODEL DEVELOPMENT

Enguri Watershed HPP Development

Friday, August 15, 2014

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DELOITTE CONSULTING LLP

USAID/CAUCASUS OFFICE OF ECONOMY, ENERGY AND ENVIRONMENT

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## 1.0 ABBREVIATIONS

| | |
|---|---|
| ABC Analysis | A way to simply prioritize alternatives using a number of assessment criteria |
| BC Ratio | Benefit-Cost Ratio |
| CBA | Cost-Benefit Analysis |
| CENN | Caucasus Environmental NGO Network |
| CICES | The Common International Classification of Ecosystem Services |
| EEC | Energy Efficiency Centre Georgia |
| GA | Green Alternative |
| GMG | Green Movement of Georgia |
| HPEP | USAID Hydropower and Energy Planning Project |
| KWh | Kilowatt-hour |
| LOE | Level of Effort |
| MA | Millennium Ecosystem Approach |
| MWh | Megawatt-hour |
| Mini-Model | A small part of a larger Cost-Benefit Model framework |
| NGOs | The five Non-Governmental Organizations that comprise the Working Group |
| RECC | REC Caucasus |
| TBSC or TBSC Consulting | Tbilisi Business Service Center, the implementer of Project |
| TEEB | The Economics of Ecosystems and Biodiversity; a framework for valuing ecosystems and biodiversity; well supported and understood by UNDP and other international organizations |
| USAID | United States Agency for International Development |
| VoLL | Value of Lost Load; a methodology for valuing the output from a new electricity generation plant, hydro- or otherwise |

## 2.0 EXECUTIVE SUMMARY

This Final Report describes the approaches taken and the work done on the Cost-Benefit Analysis Model Development Project (Project) implemented by TBSC Consulting and five NGOs with technical support from USAID Hydropower and Energy Planning Project (HPEP). This Final Report is prepared by TBSC Consulting and primarily focuses on project activities. Work began in February 2014 and finished in July 2014.

This Final Report has three Chapters. The first Chapter briefly describes Project objectives, particularly how they evolved over time. The second Chapter summarizes the approach taken in this process. The third Chapter shows how the externality costs were estimated and what were the results based on the few selected thematic areas and benefits produced from electricity output.

The CBA Model for the Enguri Watershed Area and the results were discussed with different stakeholders at CBA consultation meetings. Feedback from the meeting is recorded in Meeting Minutes attached (Appendix C) to this report.

## 3.0 PROJECT OBJECTIVES

The very broad objectives of Project are shown in the original Terms of Reference, and are shown here:

- To develop a Cost-Benefit Analysis (CBA) Model of watershed-based hydropower development in the Enguri watershed area including assessment of the environmental and social costs
- Compare the total costs and benefits accrued from the social and environmental services provided by the watershed for a baseline scenario (existing/current use) compared to the scenario in which hydropower facilities are installed.

In both objectives, the term "social and environmental" has a sense of place. As a result, most work done focused on social and environmental costs and benefits.

The development of a comprehensive cost and benefit model for an entire watershed with dozens of proposed hydropower developments is a massive undertaking, some estimates ranging to multiple years with a sizeable team of technical experts in quite a number of thematic areas. We have not done a full literature search, but we have been unable to find an example of such an undertaking anywhere in the world.[1]

Unfortunately, the data needed for such a comprehensive cost and benefit model does not exist today. In addition and clearly, Project, with a Level of Effort (LOE) of about three man-months with general management consultants, cannot produce such a result. Consequently, in consultation with HPEP, we have more narrowly focused our efforts to three objectives within the broad objectives:

- Develop a Cost-Benefit Analysis Model *framework* that shows how one would go about doing a comprehensive watershed-wide cost and benefit analysis; the audience for this is the five NGOs, Ministries and the general public
- Develop *understanding within the five NGOs* on the Cost-Benefit Analysis Model framework; the audience is the five NGOs[2]
- Elaborate a few specific elements (mini-models) of a comprehensive watershed-wide cost and benefit analysis to develop *capacity within the five NGOs* to assemble existing data and apply it to those elements; the audience is the five NGOs for the work and Ministries for the results.[3]

Noticeably absent from the objectives is information to support a particular decision regarding a particular project within the Enguri watershed. In our view, the data

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[1] Of course cost benefit analyses have been done of individual hydropower projects, or even several together. However, we have not found an example of the size of the Enguri watershed, with 27 proposed projects, not all of which are compatible with one another. This means the cost benefit analysis also needs to have an optimization sense.

[2] This objective focuses on a style of thinking that can only be developed and nurtured over an extended period of time. Consequently, it is unlikely that any work by Project could develop understanding among parties that do not participate in the Working Group.

[3] The mini-model concept is described further below. For now, a mini-model is one piece of a larger model focusing on a single area. The results for many mini-models can be added, with adjustments to avoid double counting, to give the overall result. For example, mini-models include resettlement costs (*e.g.*, viewed from the perspective of private land and structures, community infrastructure and income streams, both current and cost to restore in new location), mitigation of severe events (*e.g.*, landslides), habitats and recreation. In each case the NGO is inputting data at hand to calculate one or more measures of impact (cost).

quality and hence the cost and benefit model are not sufficiently complete to support such decisions.[4]

This has proven to be a very difficult project. Early on there was much discussion of a cost and benefit “template” that could be applied elsewhere. We checked several dictionaries to determine the actual meaning of the word “template” and found several similar definitions that seemed to fit Project:

> A document or file having a preset format, used as a starting point for a particular application so that the format does not have to be recreated each time it is used.[5]

The framework and the cost and benefit models developed by Project are good starting points for later, more detailed analysis of specific thematic or sub-thematic areas. These starting points do not need to be recreated for each use. The specific elements elaborated as part of objective three also do not need to be recreated. However, the many other mini-models (explained below) needed for a comprehensive cost and benefit model for the entire watershed will need to be elaborated if additional detail is desired in those particular areas.

The template model is a framework that will guide future analysts as they develop CBAs for watersheds. The model consists of identification of thematic areas, developing metadata sets, creating mini-models for pricing of the identified costs and benefits and the spreadsheets for calculating the various reference indicators, where “1” is the indifferent indicator.

We understand that USAID HPEP has developed an economic and financial model for determining the financial viability HPPs on the Enguri watershed. Assuming all the necessary data was available and reliable and that the thematic areas are reasonable, the template model would help guide decision-makers on which sites and which types of HPPs would provide the most positive results for Georgia. To use the model further, say to evaluate HPPs to thermal power plants, the template model would be used for selecting all appropriate thematic areas, metadata sets, mini-models and the final spreadsheets for calculating the positive or negative net indicators for each generation option.

To avoid confusion, the template under development is not comprehensive in the sense that it is a worksheet into which assumptions can be put to create an overall answer. For certain it will consider some aspects of an overall cost-benefit analysis but since it is a framework, it will not have all the various pieces that a full cost-benefit model would have. Creating such a full cost-benefit model is a multi-year effort, and in any case cannot be used in Georgia since data needed for such a model does not yet exist.

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[4] This situation should not be surprising. The 27 projects in the Enguri watershed have been under consideration for 40 years. Feasibility studies have been done on some, but not most of the projects. The feasibility studies for one project typically require months to complete with technical experts and commensurately large budgets. No watershed-wide study has ever been done. Consequently, one should not expect that Project outputs will take the place of an in-depth watershed-wide analysis.

[5] http://www.thefreedictionary.com/template.

# 4.0 APPROACH

Project work was completed in eight Steps as described in this Chapter. The work on the different Steps has overlapped somewhat.

## 4.1 Step One – Define What is Meant by Cost and Benefit Framework

As noted previously, a comprehensive watershed-wide cost and benefit analysis is many times beyond the scope of Project. Rather, we focus on a framework for such a cost and benefit analysis.

The following chart shows the framework developed by Project in consultation with HPEP. The framework (sometimes referred to as a model) is a process one must go through to estimate costs and benefits.

The first step is to decide what thematic areas one wishes to monetize. We considered a wide range of sources for an initial list of thematic areas one could consider. To the end, we used The Economics of Ecosystems and Biodiversity (TEEB) framework, though others (e.g. Millennium Ecosystem Approach, The Common International Classification of Ecosystem Services) could have been used since the objective was to ensure that a variety of thematic areas were considered. The Working Group was already very or somewhat familiar with TEEB so it was a logical starting point. In addition, the Government of Georgia has recognized TEEB as an important tool for valuation of ecosystem services.

At the start, not all thematic areas can be addressed so there is a selection step. Sub-selections need to be made within the thematic areas. These choices can be driven by the availability of data or the particularities of the cost and benefit analysis or both.

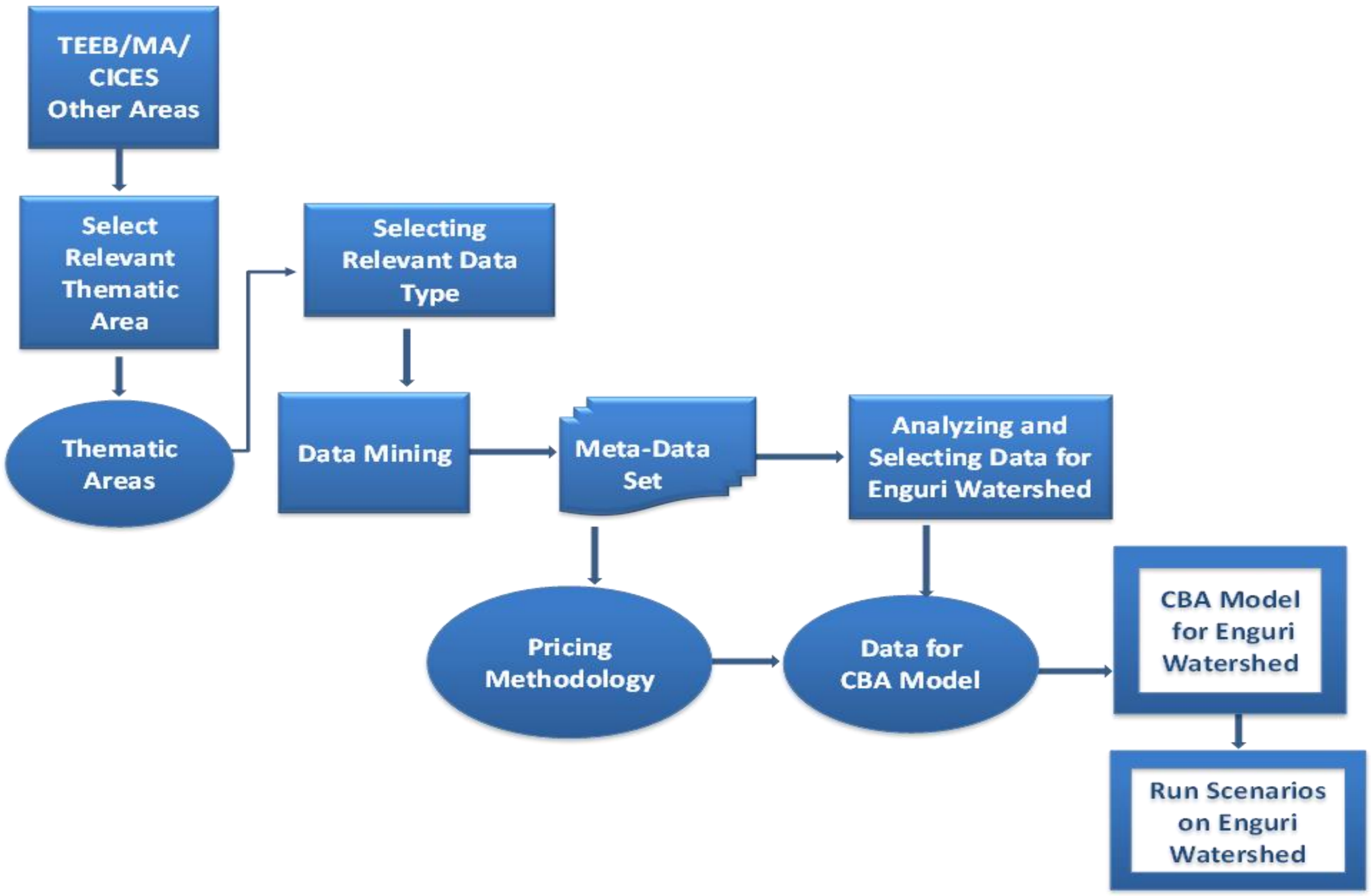
Data sources are then identified, shown as data mining in the chart.[6]. This results in available data sets. Each data set is summarized in a meta-data sense and the particular data used is chosen. This is a very problematic area if the data sets are not specific to the cost and benefit analysis purposes.

Separately, the pricing or monetization methods are selected. These are combined with the data to create estimates of costs or benefits, which can be summed after adjustments for any double-counting of costs or benefits.

This framework is applicable to any hydropower watershed in any place. The process is the same for any watershed (*i.e.*, select and prioritize thematic areas) though the later steps (*e.g.*, select pricing methodologies) vary depending on the thematic areas selected.

[6] This usage is a bit non-standard. Data mining usually means taking a given data set and extracting (mining) data from the data set. In our usage, data mining means seeking data sets that may, or may not, contain the data we seek. It is mining because, until now, there has not been an inventory of data sets that might be available.

**Cost and Benefit Framework**




**Source: TBSC Consulting and HPEP.**

## 4.2 Step Two – Decide Territory to Include

The Enguri watershed is very large, but even it is a small part of Georgia; benefits and costs of hydropower projects can extend well beyond the watershed. For example, on the benefit side electricity generated benefits the rest of Georgia and foreign markets. Limited carbon dioxide emission benefits the entire world. On the cost side, loss of recreational opportunities affects all potential visitors, be they from the watershed, the rest of Georgia or the rest of the world.

The problem was simplified using the Pareto Principle (*i.e.*, the 80-20 rule). The basic premise is that if a cost or benefit is 80 percent within a particular territory and only 20 percent in another territory, then we only consider the cost or benefit within the particular territory.

For example, the largest benefit of any hydropower project is the electricity generated. Nearly all electricity from any of the projects under consideration will be used outside the watershed. Consequently, the benefit from the electricity is assumed to be in Georgia generally, rather than within the watershed. Likewise, resettlement costs are nearly all within the watershed so only the watershed territory is used for this analysis.

## 4.3 Step Three – Decide Thematic Areas In Which Costs Will Be Monetized

The literature is rich with areas where costs and benefits of hydropower projects can be estimated. On the cost side, with the Working Group we chose to start with the basic areas noted in The Economics of Ecosystems Biodiversity (TEEB) methodology. We augmented this with the experience of the Working Group members.

In several hours of discussion in several meetings, a long list of potential thematic areas was prepared and then assessed and prioritized by the Working Group. An ABC analysis was used to do the final prioritization. The final result is shown in the following chart.

### ABC Analysis of Candidate Thematic Areas

| LN | THEMATIC AREA | NGO | | | | | TBSC ADJUSTMENT | TOTAL SCORE | FINAL CATEGORY |
|---|---|---|---|---|---|---|---|---|---|
| | | CENN | REC | EEC | GMG | GA | | | |
| 1 | Resettlement | A | A | B | A | A | | 14 | A |
| 2 | Economic Development And Employment | A | C | A | A | C | 1 | 12 | A |
| 3 | Raw Materials | B | A | A | B | B | | 12 | A |
| 8 | Moderation Of Extreme Events | C | A | B | A | A | | 12 | A |
| 4 | Fresh Water | B | C | A | C | B | 1 | 10 | B |
| 6 | Spiritual Experience And Sense Of Place | B | A | B | C | A | | 11 | B |
| 7 | Habitats For Species | A | B | B | A | C | | 11 | B |
| 9 | Tourism | A | B | A | C | B | | 11 | B |
| 13 | Mineral Resources | C | B | B | B | A | | 10 | B |
| 5 | Local Climate And Air Quality | C | B | C | B | B | | 8 | C |
| 10 | Maintenance Of Genetic Diversity | C | C | C | B | C | | 6 | C |
| 11 | Erosion Prevention And Maintenance Of Soil Fertility | B | B | C | B | C | | 8 | C |
| 12 | Carbon Sequestration And Storage | B | C | C | C | B | | 7 | C |

**Source: Working Group.**

To the end, mini-models were prepared in six thematic areas from As and Bs: resettlement; economic development and employment; raw materials; moderation of extreme events; habitats for species; and tourism.

**Benefits.** The Pareto Principle was extended to thematic area selection also. The benefits of any hydropower project are nearly all electricity. There can be other benefits, such as increase in employment due the construction and in tourism due to the newly built HPP. However, these benefits are negligible when compared to the benefit from electricity.[7] Also, a very large share of the benefit from the electricity is gained by the population outside the watershed, therefore, the Working Group decided to concentrate on electricity benefits only.

On the other hand, costs are largely a local issue. Consequently, we consider only local costs; costs due to contributing to global warming are not considered.

More information about how the benefits were calculated is given in the next Chapter.

## 4.4 Step Four – Inventory Existing Data

In this Step, we worked with each NGO to identify and document data sets that they have at hand or can (easily) obtain. Data was divided into two groups: Data sets that the NGOs have at this moment and those that can be obtained from others.

[7] HPEP assessed a new way of determining the benefit of the electricity generated: Value of Lost Load (VoLL). This will likely result in a much larger benefit than merely taking output times a tariff rate. As benefits go up, so will costs from the impact areas being considered by the mini-models and the NGOs.

## 4.5 Step Five – Decide the Monetization Method for Selected Thematic Areas and Territory

**Monetization Methods.** Working with the Working Group we first defined the general approach to monetizing a cost or benefit and then applied it specifically to resettlement and raw materials as examples.

For resettlement we summarized three general monetization methods as described in TEEB (direct market valuation, revealed preferences and stated preferences) with several sub-methods within each.

We then turned to raw materials. The valuation methods previously discussed for resettlement were also applied here.

**Mini-models.** Once monetization methods were agreed upon, we developed mini-models for the particular sub-thematic area. For example, for the private land portion of resettlement we settled on market valuation with an inventory of private land holdings.

A similar mini-model is used for the new (resettled) private land holdings. Such models have been developed for Raw Materials and Foods, Moderation of Extreme Events, Habitats for Species and Tourism.

## Source of Data not at Hand with NGOs

| | | DATA SET 1 | | DATA SET 2 | | DATA SET 3 | | DATA SET 4 | | DATA SET 5 | | DATA SET 6 | | DATA SET 7 | | DATA SET 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LN | THEMATIC AREA | Name | Who Do We Get It From | Name | Who Do We Get It From | Name | Who Do We Get It From | Name | Who Do We Get It From | Name | Who Do We Get It From | Name | Who Do We Get It From | Name | Who Do We Get It From | Name | Who Do We Get It From |
| 1 | **Resettlement** | Census data of local population (Khaishi community about 2000 people) - resettlement costs. | Land Owners Association | Annual report on hazard risks. | National Environmental Agency (NEA) | Atlas of Natural Hazards and Risks of Georgia | CENN | List of 19 potential hydro-power projects and their concepts. | HPEP; Deloitte | Data base of eco-migrants | Ministry of Refugees and Accommodation | Internal migration figures and demographical data (e.g., from Svaneti to the rest of Georgia, within Svaneti). | Geostat; Public Registry; SSA - Ministry of Health | USAID Project | Nala; Self-Government Association | Feasibility Study for Khudoni HPP | WB |
| 2 | **Economic Development And Employment** | Projections of electricity output and benefit thereof. | HPEP | Khudoni EIA: number of employees and so on. | Transelectrica | Strategy of economic development; 2020 | Government of Georgia | Strategy of Energy Sector Development (White Paper) | Ministry of Energy; HPEP | | | | | | | | |
| 3 | **Raw Materials** | Atlas of Natural Hazards and Risks of Georgia | CENN | Shape files of watershed | Public Registry | Forest Inventory | Ministry of Environment, National Forest Agency | Report on Central Caucasus Planned Protected Area | Agency of Protected Areas - APA (WB, Keti Skhireli) | | | | | | | | |
| 8 | **Moderation Of Extreme Events** | Atlas of Natural Hazards and Risks of Georgia | CENN | Annual report on hazard risks. | NEA | | | | | | | | | | | | |
| 4 | **Fresh Water** | Water cadastre of Georgia | NEA, Hydro-Meteological Department | Amount of water in the reservoirs | Water Management Institute | | Ministry of Education. Rustaveli Foundation | National Atlas of Georgia | Institute of Geography | Information on potable and irrigation water | Ministry of Regional Development and Infrastructure, Water Company LTD | Water balance in Enguri | Ilia State University; Lasha Sukhishvili | Baseline assessment for water flow | CENN | | |
| 6 | **Spiritual Experience And Sense Of Place; Cultural Heritage** | Date base of all cultural monuments in the watershed. | Agency of Cultural Heritage | Sacred places | NALA - Local governments; Svaneti Tourism Center | Data base of all potential natural monuments | APA; Nakresi | Report on Central Caucasus Planned Protected Area | Agency of Protected Areas - APA (WB, Keti Skhireli) | | | | | | | | |
| 7 | **Habitats For Species** | Flora species present | Institute of Botanics | Fauna species present | Institute of Zoology | | Biodiversity Conservation Service of Ministry of Environment | Research on biodiversity; high-value forests, eco-corridors | WWF | Eco-Regional Conservation Plan | WWF | Flora and fauna; Inventory of 27 species (mainly hunting) | Institute of Ecology | | | | |
| 9 | **Tourism** | Tourism research by Bank of Georgia | BOG website | Tourism Development in Georgia - Policy Brief; Giorgi Rajebashvili | Green Alternative | Svaneti tourism strategy; Georgia tourism strategy | GNTA website | The Georgian Way - New National Tourism Strategy; SW Associates | Available online: www.sw-associates.net | TEEB Georgia - Section on tourism | Green Alternative | ? | Svaneti Tourism Center; Zauri Chartolani | ? | Elkana | ? Tourism Development Project | CTC |
| 13 | **Mineral Resources** | All information on the mineral resources across Georgia | NEA | Mineral resources data | GMG; Academy of Science | ? | Caucasus Mineral Resources Institute (CIMS?) | | Ilia State University; Earth Sciences Institute | | Ministry of Geology | | | | | | |
| 5 | **Local Climate And Air Quality** | Doctoral theses | Academy of Sciences; Kaldani, Abashidze | | Khudoni EIA - sources on doctoral theses | | | Precipitation observations | NEA | Air quality registry | Ministry of Environment | Climate | GMG | National Communication to UNFCCC - Vulnerability profile of Svaneti (II, III) | UNDP, Marina Shvangiradze - Project Coordinator | GHG Emissions Inventory (Georgia) | Ministry of Environment |
| 10 | **Maintenance Of Genetic Diversity** | | | | | | | | | | | | | | | | |
| 11 | **Erosion Prevention And Maintenance Of Soil Fertility** | Cadastre; maps on soil, erosion | Ministry of Agriculture | Soil fertility maps | Agrarian University; Gizo Urushadze - Book on soils | Soil degradation | Institute of Geography | Atlas | CENN | Soil maps | GMG Nikoloz Inashvili | | | | | | |
| 12 | **Carbon Sequestration And Storage** | GHG Emissions Inventory (Georgia) | Ministry of Environment | Report on Potential for Carbon Sequestration of Georgian forests | UNFCCC - Focal Point, Ministry of Environment | | Lekso Gavasheli, Ilia State University | | | | | | | | | | |

***Source: Working Group.***

## 4.6 Step Six – Add Data to Mini-Models

Once the mini-models were created, we explained them thoroughly to the NGOs and had several discussions to make sure that they understood what the mini-models required.

The data used by the NGOs for the mini-models varies greatly in quality. Data quality has two aspects: accuracy and comprehensiveness. There are problems in both areas since the data being used was not collected with a future cost and benefit analysis in mind. This means that the specific values that come from the mini-models are, in many cases, not particularly precise but rather based on estimations.

However, even imprecise numbers have great value:

- They provide a sense of scale to the cost
- They highlight those areas that would benefit from customized data collection in the future[8]
- They are good teaching tools for the NGOs; if they do this once well, then they will be much better prepared to do this in the future or to ask pointed questions of others who have, or have not, done a monetization.

## 4.7 Step Seven – Select Hydropower Projects

As the required data was largely non-existent, the NGOs had to do a lot of estimations. In order to make these estimations and then the modeling feasible, the Working Group selected three hydropower projects from the 27 possible projects in the Enguri watershed. The mini-models were completed for those three:

- Pari B
- Mulkhura B
- Enguri 6 B.

The main factors considered during the selection of the hydropower projects are described listed below:

[8] If a particular sub-thematic area mini-model was to show large values (*i.e.*, large costs) and if the values were sensitive to the quality of the data, then that would be a prime candidate for future customized data collection.

**Factors for Selection of Hydropower Projects**

| LN | FACTORS | PARI B | MULKHURA B | ENGURI 6 B |
|---|---|---|---|---|
| 1 | **Resettlement Needed** | Yes | No | No |
| 2 | **Expected Operational Period** | Long (100 years) | Medium (50 years) | Medium (50 years) |
| 3 | **Relative Data Availability** | Medium | High | High |
| 4 | **Type Of HPP** | Large reservoir | Run-of-river | Run-of-river |
| 5 | **Location Of HPP** | Down-stream | Up-stream | Up-stream |
| 6 | **Estimated Impact On Biodiversity And Ecosystem Services** | High | Medium | Low |
| 7 | **Estimated Likelihood Of High Impact On Cultural Heritage** | High | Low | Low |
| 8 | **Capacity And Generation** | High | Medium | Medium |

**Source: TBSC Analysis.**

Also, these three projects are highly interrelated – building the large reservoir for Pari increases its capacity (from 100 MW to 180 MW; it becomes Pari B) and substantially decreases the capacity for Enguri 6 (from 34 MW to 6,5 MW; it becomes Enguri 6 B). Therefore, we looked at “Scenario B”, which is the case when all three projects are constructed.

In Appendix A, you will see the detailed descriptions of each project prepared by the EEC.

### 4.8 Step Eight – Consolidate the Data from Mini-Models

Finally, all data provided by the NGOs through the mini-models were consolidated to produce the results. These results are described in the next Chapter.

# 5.0 RESULTS

Once the NGOs completed all mini-models, TBSC did the consolidation. It is worth noting again that the mini-models and the consolidation of them only serve the purpose of the framework and therefore, have their limitations:

- The results show costs for selected externalities; as mentioned previously, many if not most externalities are not considered because only selected thematic areas were addressed
- It shows how one goes about estimating the cost of externalities (i.e., items with large costs warrant more detailed work)
- It is based on the data available.

However, the mini-models and the consolidated template correctly estimates externality costs based on the data provided.

## 5.1 General Method

Most externality costs are periodic and long-lived. This means that the cost for a single year is estimated in a variety of ways. Those numbers are then used to calculate the present value of a 50-year annuity considering the time value of money (*i.e.*, 12 percent per year).

Unlike other thematic areas, resettlement is a one-time cost and therefore, the amount is estimated without adjustments for time value of money. Resettlement also includes 25 000 GEL per household that has income stream disrupted. The frame for this was one household for a two or three year period as a maximum.

Establishment of plant species in new areas is also largely a one-time cost, so the annuity approach was not used for this externality cost.

## 5.2 Benefits

As described earlier, for simplification purposes, the only benefit taken into account in this framework was the output of electricity.

Typically, the value of electricity is merely the tariff rate times output. This approach has the advantage of simplicity, but unfortunately the tariff is a negotiated rate that is often not particularly related to the economic benefit actually produced.[9] As a result, we used two different methods to calculate benefits. The first was the usual tariff approach. The second was a more economically sound method called Value of Lost Load (VoLL).

**Tariff.** HPEP calculated the approximate tariff that the provider of capital would receive or require from selling electricity for each of the three projects. This is benefit that essentially goes to the providers of capital.[10]

[9] Obviously, if the actual economic benefit was less than a proposed tariff then the buyer would not agree to the tariff. Likewise, if the proposed tariff was less than the cost of production, then the seller would not agree to the tariff.

[10] The term “providers of capital” includes all stakeholders that supply capital to the project. This includes investors and lenders. The benefit to the providers of capital would be value based on tariff minus the operating costs. This amount would flow to lenders as interest and return of principal and to investors as dividends.

In the Appendix B, there are calculations of the tariffs for each project.

Dividing benefit (tariff rate times quantity) by external costs (noted previously) gives one Cost-Benefit measure.

**VoLL.** As noted previously, a tariff is a negotiated rate; it is not an economic rate. There are different ways one might estimate an economic rate for benefits. One emerging method is to use a concept known as Value of Lost Load. HPEP estimated the VoLL for Georgia. VoLL is the average willingness of what consumers are ready to pay to avoid an interruption of supply. VoLL is expressed in dollars per each megawatt-hour ($/MWh) of electricity not delivered.

VoLL considers that buyers of electricity are actually buying a bundle of at least two separate matters. The first is the electricity itself. The second is the reliability of access to electricity. For a particular consumer, the utility received from electricity comprises the utility received from the electricity itself plus the utility received from the reliability of access to electricity.[11]

Consumers differ greatly in how they value the two types of utilities. Some consumers would place normal utility on the electricity itself and place relatively small utility on reliability. For example, households might consider a five minute service interruption merely a minor inconvenience; this means they give low utility to reliability though if you were to add up that low utility among thousands of customers the total utility related to reliability could be quite large.

On the other hand, a five minute service interruption would cause very large problems and costs for some industrial customers; often these customers invest in expensive uninterruptable power supplies as a result. For this type of customer the utility that comes from reliability is quite high.

VoLL is an averaged measure of value that consumers attach to increased reliability, or said differently, the value they attach to not suffering a service interruption. VoLL would likely be low for the household noted above and high for the industrial customer.

VoLL is a complex concept. To estimate VoLL one must do surveys to understand the utility that different types of customers attach to reliability (or to not losing service). For a particular moment in time, one must consider how adding one more generator or high-voltage transmission line to the base would increase reliability. If reliability increases, one must understand what measures firms will take to deal with improved reliability.[12]

VoLL can be imagined as a change in consumer surplus if one is very careful in defining what is shown along the horizontal axis. Normally, “quantity” is shown along the horizontal axis. However, the horizontal axis can also be viewed as “utility”,

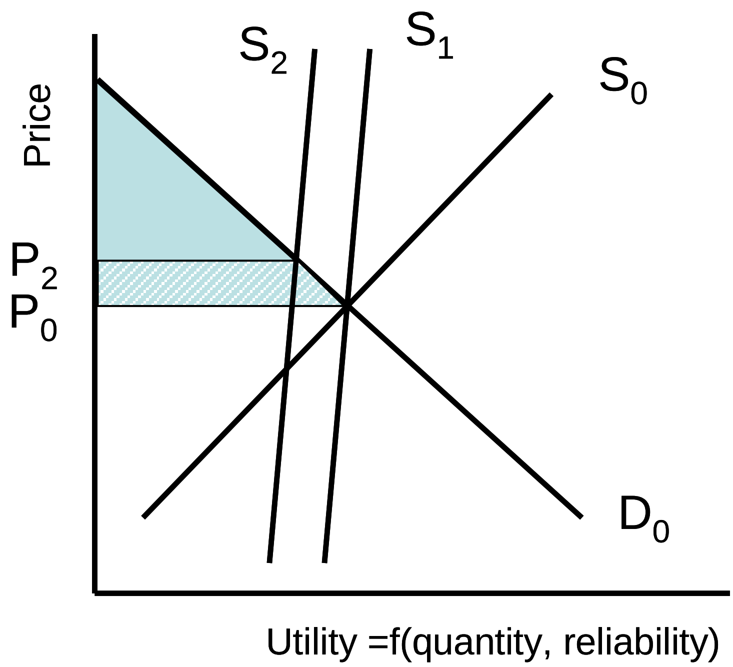
[11] More correctly, the utility coming from not losing service.

[12] These effects were very apparent in Georgia among households between 2000 and today. In 2000 electricity supply was very unreliable. Many households purchased generators; this was their way of dealing with poor reliability (coping costs). As soon as supply was lost the generators would start and one could hear them throughout the city. Today, reliability is much better. When there is the occasional outage there are essentially no generators that are started. Households have changed their behavior in regard to reliability and sold their generators. One can expect firms to do likewise as additional assets are added to the grid that increase reliability.

considering that utility is a function of both normal quantity (i.e., kWh) and reliability (i.e., some measure of not losing service).[13]

Taken in this way, demand and supply curves operate in the usual way. In the medium- to long-term, as price falls, the amount of utility (quantity, the amount of the bundle of kWh and reliability) demanded increases. This is a normal demand curve shown as $D_0$ in the following chart. In the medium- to long-term, as price increases, the amount of utility supplied (quantity) increases. This is a normal supply curve shown as $S_0$.

As is usually the case, the area under the demand curve and above the market price is consumer surplus. This is the area of the solid and cross-hatched areas in the chart. This consumer surplus is different than is usually conceived because what is shown along the horizontal axis is utility, not (only) quantity. As a result, doing a simple multiplication (like 2000 kWh X 0,10 USD/kWh) is not possible.




These normal supply and demand curves also behave in the usual manner when considered in the very short-term; the supply curve becomes nearly vertical. This is shown as $S_1$ in the chart.[14]

In some respects, this decrease in consumer surplus can be considered to be the VoLL, though one must be careful in interpretation. This is because those consumers who might be at the far left of the demand curve (i.e., those consumers who have the highest consumer surplus when only quantity is along the horizontal axis) may not be

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[13] An alternative treatment is to keep the usual meanings for price and quantity but add a third dimension for reliability. In this case the supply and demand curves become supply and demand surfaces (in three-dimensional space) and consumer surplus is no longer an area, but it becomes a volume (also in three-dimensional space).

[14] This is where consumer surplus fails. In the very short-term the price cannot change. Price is fixed, demand exceeds supply, and there is no way for the market to adjust. If we could identify the customers in the small green triangle, between the two vertical supply curves, then we could say that this is consumer surplus that is lost. But since we do not know where the particular customers who lost power are on the demand curve, we really cannot measure their loss on the chart.) In the very short-term, if there is a supply disruption the vertical supply line shifts to the left (lower supply), shown as S2 on the chart. This causes consumer surplus to fall.

the same consumers that would be at the far left if utility (combining both quantity and reliability) was used along the horizontal axis. Some very high margin businesses could afford high electricity costs but are relatively indifferent to reliability. These businesses would be at the left of the demand curve in the usual case. If we consider utility, they might not be there. A counter-example is aluminum smelters which require very cheap but very reliable electricity. Normally, their consumer surplus would be small. However, if one considers the cost of supply interruption to the industry, they would move much to the left and their consumer surplus, from the perspective of utility, would be much greater.

VoLL varies greatly from country to country and there are different methods used to calculate this figure. In Georgia, such concept has not been developed so far and therefore, there are no current value(s) of VoLL. More importantly, no surveys have been conducted and electricity data and GDP by sectors do not exist. For this reason, HPEP used the only viable option in these circumstances – VoLL for other countries as a proxy for Georgia.

Based on the literature review, the proposed range applicable for developing countries is 1-5 $/kWh. For this CBA analysis 1 $/kWh is used.

Once the value based on tariff is subtracted from the value of electricity based on VoLL, we get the benefit created for the energy security of Georgia.

## 5.3 Externality Costs

As mentioned above, externality costs were estimated in five areas:

- Habitats for Species: cost of mitigation of loss of plant species as proxy for value of species
- Moderation of Extreme Events: change in expected loss from extreme events
- Tourism (recreation): change in spending by visitors as proxy for change in value received plus change in value received by locals from visitors
- Raw Materials and Foods: change in income from timber, fuel wood and mushrooms at forest edge
- Resettlement: estimated value of replacement land, structures, community assets and other private assets.

To reiterate, these externality costs are not comprehensive. Other, not considered externality costs could equal those noted here.

### 5.3.1 Habitats for Species

For plant species, the cost of mitigation of loss of plant species was used as proxy for value. Three species were selected for each project. GMG estimated the portion of that species in Georgia that will be affected – percentage lost and adversely affected. In addition, the cost of establishing same species in new but similar territory was estimated. This includes:

- Seed/seedling costs
- Planting
- Cultivation.

For example, the cost of establishing one of the species (*Campanula trautvetteri*), which is now spread over 1 800 ha in Enguri 6 was 1,2 million GEL. The results for three species were taken as representative of 25 species for each project and the value was grossed up accordingly.

The loss of habitat for migratory birds was also considered. However, it was not possible to value loss of habitat. In any case, the loss is mostly outside the watershed so it is not an externality to include because of the simplification process that the WG went through and the rules that it established for this framework. Yet the loss of habitat is generally very important.

### 5.3.2 Moderation of Extreme Events

In order to calculate the cost created by the extreme events, the change in expected loss from extreme events was estimated. For this, Green Alternative created a standard location with standard extreme events, standard frequency and standard losses from those events.

First, *ex ante* estimations were done for the settlements in project areas:

- Relative size of settlement vis-à-vis the standard location
- Relative frequency of the extreme event in those places vis-à-vis the standard location
- Calculate expected annual cost
- Convert expected annual cost to a 50-year annuity

To monetize the likely impact of the hydropower projects, *ex post* conditions were estimated, which led to calculating the change in frequency and severity of each event caused by building the HPP. Then the expected annual loss amount was converted to a 50-year annuity. The comparison of *ex post* and *ex ante* annuity values showed that the expected change is large, *e.g.*, 13 million GEL increased loss for Pari B.

### 5.3.3 Recreation

The monetization of the value lost from recreation was estimated by using the change in time and money spent by visitors as a proxy for change in value received. There were several elements for each location. First, the number of visitors were estimated by type, both for *post* and *ex ante*. Next GMG estimated the travel time and time-in-location, which was multiplied by value of that time. GMG also estimated travel costs, added local and non-local spending by visitor. The sum value was then used to calculate a 50-year annuity. For example, for Enguri 6 B, a loss of 25 million GEL was estimated.

If double-counting of visitors among projects is considered, then one-third of this amount should be assigned to each project.

Another aspect of this thematic area is change in value received by locals from visitors. For each location again the number of visitors by type, both for *post* and *ex ante* was used. In this case, GMG estimated the local spending by visitors and margin earned by locals. Separately from that, non-local spending by visitors (e.g., with travel agencies) was estimated along with the portion of that spending that is passed on to locals and margin earned by locals. The sum value was then used to calculate a 50-year annuity. For example, loss of 2,1 million GEL was estimated for Enguri 6 B. This number is reduced to 0,7 million GEL if double-counting of visitors is considered.

### 5.3.4 Raw Materials and Foods

For this thematic area, the figures were calculated by estimating the change in income from timber, fuel wood and mushrooms at the forest edge. For this purpose, the project territory was divided into three areas:

- Area A: in the immediate area affected, the source is lost forever
- Area B (annular ring): in the area surrounding it, access to the source is lost (or gained) and renewable rate may decrease (or increase)
- Area C: in the rest of the area, the rate of renewal decreases (or increases).

In this thematic area, RECC estimated two main figures: *ex ante* and *ex post* natural productivity (or the renewable rate) in each area and the changes in access due to the building the hydropower project.[15] Along with that, RECC estimated forest-edge price for each type of raw material or food. The price was then multiplied by quantity and collection costs were subtracted from it to give *ex ante* and *ex post* value.

The annual sum was then used as the basis for a 50-year annuity. For example, for timber, fuel and mushrooms in Pari- B the value of change is 265 million GEL.

### 5.3.5 Resettlement

In order to calculate the approximate cost of resettlement, CENN estimated value of replacement land, structures, community assets and other private assets. For each project, CENN gathered information and made estimations about the number of households and their local assets (*e.g.*, land of different types, homes, outbuildings, community fields). These numbers were then summed by type and an average value was applied to give replacement cost. The costs for loss of income streams for affected households were added to that figure. As a result of the calculation, for example, for Pari-B 36 million GEL was the total resettlement cost:

- 33 million GEL for asset losses and replacements
- 3,3 million GEL for loss of income streams.

There appears to be no resettlement needs for Enguri 6-B and Mulkhura and therefore this thematic area does not affect those projects.

[15] The renewable rate refers to the amount of raw material or food that can be collected in a renewable manner or so that the same amount could be collected in the years to come. This may well be more or less than the amount that is presently collected. That is, over or under-exploitation is more likely than correct exploitation.

### 5.3.6 Results by Project

This Section gives the calculations for the individual projects. One can see the estimated present values for externality costs by sub-thematic area, the construction costs and the electricity output.

**Enguri 6 B**

| TYPE OF EXTERNAL COST | CAPITALIZED VALUES (50 year annuity) | | | |
|---|---|---|---|---|
| | EX ANTE | EX POST | CHANGE | |
| Cost Of Mitigation Of Loss Of 25 Plant Species (sample of three plant species) | n.a. | n.a. | (11 589 300) | |
| Expected Loss From Extreme Events | (45 989 601) | (56 984 789) | (10 995 189) | |
| Value Received By Recreational Visitors | 35 314 880 | 10 026 021 | (25 288 859) | |
| Value Received By Locals From Recreational Visitors | 2 939 792 | 830 118 | (2 109 675) | |
| Value Of Timber | 429 100 267 | 387 890 787 | (41 209 481) | |
| Value Of Fuel Wood | 470 799 666 | 425 585 503 | (45 214 164) | |
| Value Of Mushrooms | 7 566 423 | 8 074 106 | 507 683 | |
| Cost Of Resettlement | 0 | 0 | 0 | |
| **Partial Total For Externalities** | **899 731 429** | **775 421 744** | **(135 898 984)** | |
| Present Value Of Construction Cost | n.a. | n.a. | (18 460 475) | **Benefit ÷ Cost** |
| Present Value Of Output Based On Tariff | n.a. | n.a. | 27 777 279 | 0,180 |
| **Overall Present Value Based On Tariff** | **899 731 429** | **775 421 744** | **(126 582 180)** | |
| Present Value Of Output Based On VoLL | n.a. | n.a. | 394 871 124 | 2,558 |
| **Overall Present Value Based On VoLL** | **899 731 429** | **775 421 744** | **240 511 665** | |

**Source: GMG, GA, RECC, CENN, EEC, HPEP, TBSC Analysis.**

*Note: Please recall: This chart shows costs for selected externalities; many if not most externalities are not considered; actual externality costs could be several times those shown here. This chart shows how one goes about estimating the cost of externalities. This chart is based on the data available. This correctly estimates externality costs for the data provided.*

The Benefit to Cost ratio is shown in two very different ways: in the first one, the present value is based on using the estimated tariff for Enguri 6-B output while calculating the benefit from electricity; in the second option, the present value is based on using VoLL. Clearly, the benefits calculated by using the tariff is much lower ($71,34 per MWh). Therefore, the Benefit to Cost ratio in that case is less than one (about 0,18). On the other hand, using the VoLL ($1 per kWh) gives a Benefit to Cost ratio of 2,6).

As we said earlier, the benefits calculated based on tariff (minus the operating costs) can be viewed as the benefits that go to the providers of capital while the benefits based on VoLL (minus the amount based on the tariff) can be interpreted as the value added to the energy security of Georgia.

Below you will see the same chart but with additions: this chart is designed to give insights about what party is most likely to bear the different costs if the HPPs are built.

### Enguri 6 B: Parties that Bear the Cost

| TYPE OF EXTERNAL COST | CAPITALIZED VALUES (50 year annuity) EX ANTE | EX POST | CHANGE | COMMENT | |
|---|---|---|---|---|---|
| Cost Of Mitigation Of Loss Of 25 Plant Species (sample of three plant species) | n.a. | n.a. | (11 589 300) | Cost probably paid by Government if it commissions replanting. | |
| Expected Loss From Extreme Events | (45 989 601) | (56 984 789) | (10 995 189) | Cost covered by local citizens and Government, depending on adequacy of Government reparations. | |
| Value Received By Recreational Visitors | 35 314 880 | 10 026 021 | (25 288 859) | Cost mostly borne by foreign tourists. | |
| Value Received By Locals From Recreational Visitors | 2 939 792 | 830 118 | (2 109 675) | Cost entirely borne by local businesses. | |
| Value Of Timber | 429 100 267 | 387 890 787 | (41 209 481) | Cost entirely borne by local businesses. | |
| Value Of Fuel Wood | 470 799 666 | 425 585 503 | (45 214 164) | Cost entirely borne by local businesses. | |
| Value Of Mushrooms | 7 566 423 | 8 074 106 | 507 683 | Cost entirely borne by local businesses. | |
| Cost Of Resettlement | 0 | 0 | 0 | Cost probably borne by providers of capital. | |
| **Partial Total For Externalities** | **899 731 429** | **775 421 744** | **(135 898 984)** | | |
| Present Value Of Construction Cost | n.a. | n.a. | (18 460 475) | Cost borne by owner. | **Benefit ÷ Cost** |
| Present Value Of Output Based On Tariff | n.a. | n.a. | 27 777 279 | Entire benefit received by providers of capital | 0,180 |
| **Overall Present Value Based On Tariff** | **899 731 429** | **775 421 744** | **(126 582 180)** | | |
| Present Value Of Output Based On VoLL | n.a. | n.a. | 394 871 124 | Most of benefit received by population (difference between this and present value of output based on tariff). | 2,558 |
| **Overall Present Value Based On VoLL** | **899 731 429** | **775 421 744** | **240 511 665** | | |

**Source: GMG, GA, RECC, CENN, EEC, HPEP, TBSC Analysis.**

The chart below gives the same items for Pari B.

## Pari B

| TYPE OF EXTERNAL COST | CAPITALIZED VALUES (50 year annuity) EX ANTE | EX POST | CHANGE | Benefit ÷ Cost |
|---|---|---|---|---|
| Cost Of Mitigation Of Loss Of 25 Plant Species (sample of three plant species) | n.a. | n.a. | (24 731 667) | |
| Expected Loss From Extreme Events | (122 660 852) | (191 629 969) | (68 969 117) | |
| Value Received By Recreational Visitors | 35 314 880 | 10 026 021 | (25 288 859) | |
| Value Received By Locals From Recreational Visitors | 2 939 792 | 830 118 | (2 109 675) | |
| Value Of Timber | 432 378 572 | 364 548 662 | (67 829 910) | |
| Value Of Fuel Wood | 474 396 552 | 399 975 021 | (74 421 531) | |
| Value Of Mushrooms | 8 439 836 | 8 647 342 | 207 506 | |
| Cost Of Resettlement - Assets | n.a. | n.a. | (35 784 770) | |
| **Partial Total For Externalities** | **830 808 781** | **592 397 195** | **(298 928 022)** | |
| Present Value Of Construction Cost | n.a. | n.a. | (416 117 267) | **Benefit ÷ Cost** |
| Present Value Of Output Based On Tariff | n.a. | n.a. | 759 952 671 | 1,063 |
| **Overall Present Value Based On Tariff** | **830 808 781** | **592 397 195** | **44 907 381** | |
| Present Value Of Output Based On VoLL | n.a. | n.a. | 11 316 154 471 | 15,826 |
| **Overall Present Value Based On VoLL** | **830 808 781** | **592 397 195** | **10 601 109 181** | |

**Source: GMG, GA, RECC, CENN, EEC, HPEP, TBSC Analysis.**

*Note: Please recall: This chart shows costs for selected externalities; many if not most externalities are not considered; actual externality costs could be several times those shown here. This chart shows how one goes about estimating the cost of externalities. This chart is based on the data available. This correctly estimates externality costs for the data provided.*

The Benefit to Cost ratio is much higher for Pari-B. Based on tariff ($68,76 per MWh), it gives a number slightly bigger than one: 1,1. Based on VoLL, the BC ratio is very high – 15,8.

## Mulkhura B

| TYPE OF EXTERNAL COST | CAPITALIZED VALUES (50 year annuity) | | | |
|---|---|---|---|---|
| | EX ANTE | EX POST | CHANGE | |
| Cost Of Mitigation Of Loss Of 25 Plant Species (sample of three plant species) | n.a. | n.a. | (21 131 025) | |
| Expected Loss From Extreme Events | (80 401 305) | (113 755 210) | (33 353 905) | |
| Value Received By Recreational Visitors | 35 314 880 | 10 026 021 | (25 288 859) | |
| Value Received By Locals From Recreational Visitors | 2 939 792 | 830 118 | (2 109 675) | |
| Value Of Timber | 429 100 267 | 387 890 787 | (41 209 481) | |
| Value Of Fuel Wood | 470 799 666 | 425 585 503 | (45 214 164) | |
| Value Of Mushrooms | 7 566 423 | 8 074 106 | 507 683 | |
| Cost Of Resettlement | n.a. | n.a. | 0 | |
| **Partial Total For Externalities** | **865 319 724** | **718 651 324** | **(167 799 425)** | |
| Present Value Of Construction Cost | n.a. | n.a. | (53 801 020) | **Benefit ÷ Cost** |
| Present Value Of Output Based On Tariff | n.a. | n.a. | 123 316 073 | 0,556 |
| **Overall Present Value Based On Tariff** | **865 319 724** | **718 651 324** | **(98 284 373)** | |
| Present Value Of Output Based On VoLL | n.a. | n.a. | 1 822 175 531 | 8,223 |
| **Overall Present Value Based On VoLL** | **865 319 724** | **718 651 324** | **1 600 575 086** | |

**Source: GMG, GA, RECC, CENN, EEC, HPEP, TBSC Analysis.**

*Note: Please recall: This chart shows costs for selected externalities; many if not most externalities are not considered; actual externality costs could be several times those shown here. This chart shows how one goes about estimating the cost of externalities. This chart is based on the data available. This correctly estimates externality costs for the data provided.*

For Mulkhura B, the Benefit to Cost ratio based on tariff ($68,70 per MWh) is less than one: 0,6. The Benefit to Cost ratio based on VoLL is very high: 8,2.

As it was mentioned earlier, these calculations (for example, the electricity output of each project) were done for Scenario B, which means building not just the individual projects but rather all three of them. Therefore, below you see the combined cost and benefit figures:

### Scenario B: All Three Projects – Pari-B, Enguri 6-B, Mulkhura-B

| TYPE OF EXTERNAL COST | CAPITALIZED VALUES (50 year annuity) | | | |
|---|---|---|---|---|
| | EX ANTE | EX POST | CHANGE | |
| Cost Of Mitigation Of Loss Of 75 Plant Species (sample of nine plant species) | n.a. | n.a. | (57 451 992) | |
| Expected Loss From Extreme Events | (249 051 757) | (362 369 968) | (113 318 211) | |
| Value Received By Recreational Visitors | 35 314 880 | 10 026 021 | (25 288 859) | |
| Value Received By Locals From Recreational Visitors | 2 939 792 | 830 118 | (2 109 675) | |
| Value Of Timber | 1 290 579 107 | 1 140 330 235 | (150 248 871) | |
| Value Of Fuel Wood | 1 415 995 885 | 1 251 146 026 | (164 849 859) | |
| Value Of Mushrooms | 23 572 682 | 24 795 555 | 1 222 872 | |
| Cost Of Resettlement | n.a. | n.a. | (35 784 770) | |
| **Partial Total For Externalities** | **2 519 350 589** | **2 064 757 986** | **(547 829 365)** | |
| Present Value Of Construction Cost | n.a. | n.a. | (488 378 763) | **Benefit ÷ Cost** |
| Present Value Of Output Based On Tariff | n.a. | n.a. | 911 046 022 | 0,879 |
| **Overall Present Value Based On Tariff** | **2 519 350 589** | **2 064 757 986** | **(125 162 105)** | |
| Present Value Of Output Based On VoLL | n.a. | n.a. | 13 533 201 126 | 13,060 |
| **Overall Present Value Based On VoLL** | **2 519 350 589** | **2 064 757 986** | **12 496 992 999** | |

**Source: GMG, GA, RECC, CENN, EEC, HPEP, TBSC Analysis.**

Based on the selected externality costs, the construction costs and the value of electricity the Benefit to Cost ratio for these three projects together is less than one using the tariffs and about 13 using VoLL.

## 6.0 APPENDIX A: DESCRIPTION OF HYDROPOWER PROJECTS


**Information on Selected HPPs in the Enguri Watershed Area**
**Pari HPP, Mulkhura HPP, Enguri 6 HPP,**

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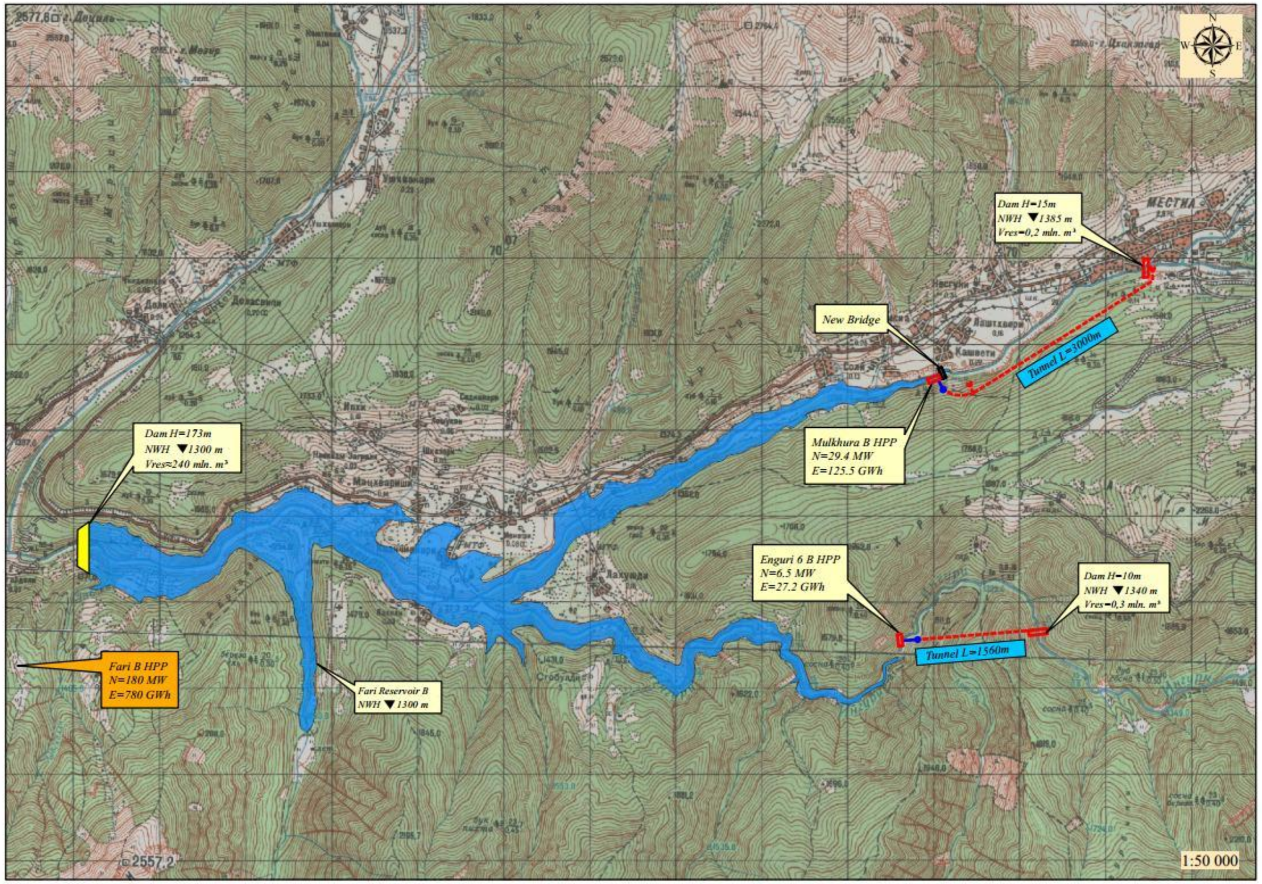
Brief information about hydropower plants , planned to be constructed on river Enguri in Mestia district northern Georgia’s Samegrelo-Upper (Zemo) Svaneti Region

## PARI HPP

Pari HPP was originally designed with 173 m dam, with about 240 Mm3 reservoir volume. Designed capacity of original Pari HPP scheme composes 180 MW and generation 780 GWh. (See Drawing 1)
Pari HPP presents seasonal regulation HPP, when Mulkhura and Enguri HPP are run-off river schemes. Regulation is more advantageous from energy production point of view, however big reservoirs always cause environmental issues.
No detail information on Pari HPP are available at this stage.

Drawing 1 Pari HPP 173m



**MAIN CHARACTERISTICS OF MULKHRA HPP, ENGURI 6 HPP AND PARI HPP SCHEMES**

Table 1

| | **Units** | **Mulkhura HPP** | **Enguri 6 SHPP** | **Pari Hpp** |
|---|---|---|---|---|
| Upstream | masl | 1385 | 1340 | 1180 |
| Downstream | masl | 1310 | 1310 | 1060 |
| Head | m | 75 | 30 | 250 |
| Capacity | MW | 29.4 | 6.5 | 180 |
| Generation | GWh | 125.5 | NA | 780.0 |
| Diversion length | m | 3000 | NA | - |
| Cost | Mln USD | 38.4 | NA | 297.0 |
| Unit Cost | USD/KW | 1305 | NA | 1700 |

**MULKHURA HPP**

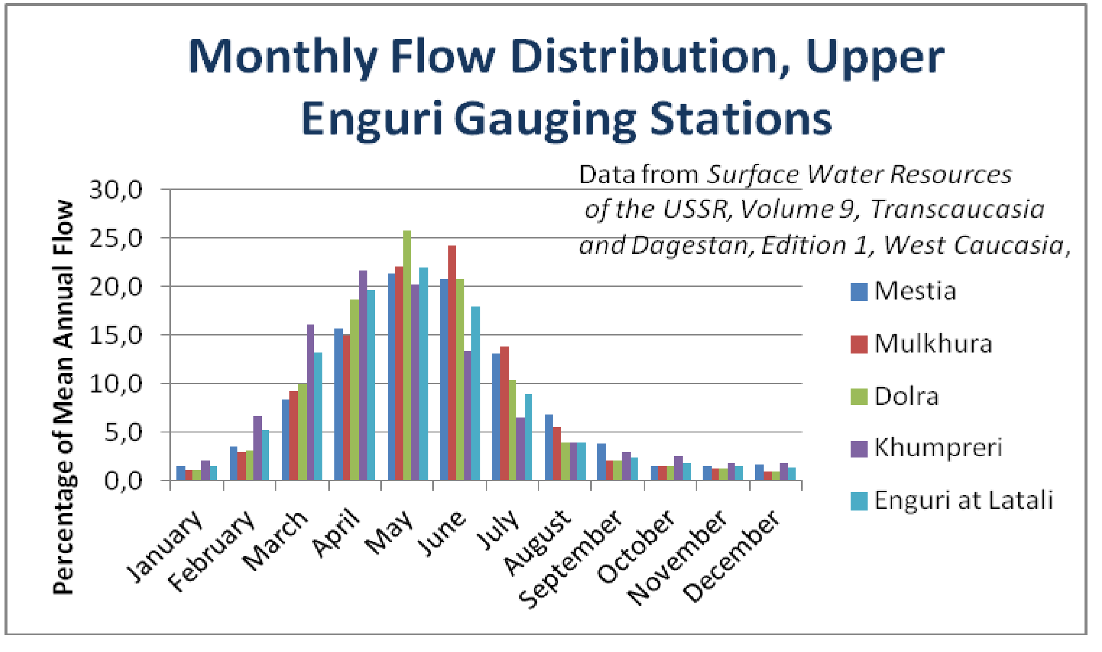
**Executive Summary**

There are two scenarios for the development of Mulkhura HPP—with construction of the proposed Pari Dam height 173 m and Reservoir volume 240 Mln.$m^3$ ( see drawing 1 ) and with construction of the proposed Pari HPP with dam height to 50m and reservoir volume 5.6 Mln.$m^3$ ( see drawing 1 ).

We will concentrate on the scenario N1 with Pari dam height 173m.

The gross head will be about 75 m, plant capacity will be about 29.4 MW, and average annual generation will be about 125 GWh.

Mulkhura HPP is located on a major right-bank tributary of the Enguri River, with the power plant located near the mouth of the Mulkhura. The Mulkhura River watershed lies on the south slope of the Greater Caucasus Mountain Range. The river is steep in the reach below Mestia, providing a very good opportunity to develop a project that is expected to be quite financially attractive. The river flows in Upper Svaneti are very seasonal. Discharges are low during winter months when most precipitation falls as snow, and are high during spring and summer when melt-water and rain runoff are combined. The variability is demonstrated in the following chart, which shows the seasonality of flow at gauging stations in the upper Enguri River basin

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There is not enough data on sediment loads for the Mulkhura and Mestiatchala Rivers. Control measures will be required.
The diversion point for Mulkhura is just below the confluence with the Mestiatchala River, and immediately downstream from the center of Mestia. The power plant is about 10 km downstream, in the area where the Enguri and Mulkhura Rivers join.
The preliminary project layout, based on information available at this time, includes a low diversion dam with sluice, a tunnel water conductor, penstock, a surface powerhouse, open cut channel tailrace, substation, and a transmission line. Three Francis turbines will be used .
Local officials from Mestia discussed this project during HIPP's reconnaissance visit to Svaneti. They are very supportive of this particular project, since it could probably be built without relocating any residents at all, has a significant installed capacity, and is in the center of the population and electric load growth area.

### Project cost and construction schedule

The estimated cost of the Mulkhura HPP (with Pari project) is US$ 38.4 million, or about US$ 1,305/kW of installed capacity, including VAT and a 25% contingency. The project is expected to have a 1-year pre-construction period and 3-4-year construction period. The critical path for the project may be controlled by the tunnel construction or by the procurement, manufacture, delivery and installation of major mechanical and electrical components.

### Conclusions

According to preliminary assessment, the plant offers a good potential opportunity to sell modest amounts of energy during three winter months inside Georgia, replacing (displacing) expensive thermal power; and to export energy during the remainder of the year to take advantage of the seasonal differentials in power prices between Georgia and its neighboring countries.

**Table 2: Project Significant Data**

| **General** | |
|---|---|
| Project name | Mulkhura Hydropower Project |
| Project location (political) | Mestia District of northern Georgia's Samegrelo– Upper (Zemo) Svaneti Region |
| Nearest town or city | Mestia |
| River name | Mulkhura River |
| Watershed name | Mulkhura River Watershed |
| Drainage area at diversion | 382.8 $km^2$ |
| **Financial Estimates** | |

| | |
|---|---|
| Estimated construction cost, including VAT | $35 Million |
| Estimated cost per kW capacity | $ 1,305/kW |
| **Hydrological Data** | |
| Stream gauge used | Mestia and Mulkhura at mineral springs gauging stations |
| Years of record | 1939, 1940, 1942, 1943, 1946-80 (Mestia) 1962-80 (Mulkhura) |
| Gauge drainage area | 144 $km^2$ (Mestia); 197 $km^2$ (Mulkhura) |
| Mean river flow at intake | 29.45 $m^3/s$ |
| Facility design discharge | 50 $m^3/s$ |
| Preliminary design flood (100 yr return period) (Adjusted to Intake Location) | 439 $m^3/s$ |
| Max. recorded flow (gauging station) | 351 $m^3/s$ (Mestia); 94 $km^2$ (Mulkhura) |
| Mean annual flood (gauging station) | 75 $m^3/s$ (Mestia); 58.4 $km^2$ (Mulkhura) |
| **Diversion Facilities** | |
| Normal operating level | 1,385 masl |
| Approximate dam height | 15 m |
| Approximate diversion pond area | 1.8 ha |
| De-silting structure | Not required |
| Sanitary or environmental bypass flow (assumed) | 10% of mean monthly flow during low - water season and 10% of mean annual flow for the rest of the period |
| **Power Tunnel** | |
| Tunnel length | 3,000 m |
| Tunnel section (diameter) | 4.5 m |
| **Penstock** | |
| Penstock length | 2x150 m |
| Outside diameter | 3,600 mm |

| **Powerhouse** | |
|---|---|
| Type | Above-ground |
| Installed capacity | 29.4 MW |
| Units, turbine output and turbine type | 2 x 12.6 MW & 6.3 MW Francis |
| Units and rated generator capacity | 2 x 17.3 MVA & 8.7 MVA at 0.90 Power Factor |
| Preliminary generator voltage | 10 kV or 6.3 kV |
| Rated speed | 214.3 rpm; 300 rpm |
| Units, type and net capacity at high-voltage transformer | 2; 35/10-20 MVA & 35/10-12.5 MVA or 2; 35/6.3-20 MVA &35/6.3-12.5 MVA |
| **Tailrace** | |
| Length | 30 m |
| Width | 20 m |
| Type | Open channel |
| Normal tail water elevation | 1,310 masl |
| **Transmission line** | |
| Interconnection location | New 35 kV |
| Distance to interconnection (km) | 2 km |
| Voltage | 35 kV |
| **Power & Energy** | |
| Gross head | 75 m |
| Total head loss at rated discharge | 5.6 m |
| Net head at rated discharge | 69.4 m |
| Estimated average annual generation | Approximately 125.5 GWh |
| Nominal installed capacity | 29.4 MW |
| Preliminary annual plant factor | 49 % |
| **Construction Period** | **Option B** |
| Conceptual design, feasibility studies & EIA | 1 year |

| | |
|---|---|
| Engineering, procurement and construction | 4 years |
| Ongoing environmental monitoring | Some studies and data collection will extend throughout construction. |
| **Environmental** | |
| Critical environmental receptors | Svaneti Planned Protected Areas |

## GENERAL INTRODUCTION OF THE PROJECT

**Table 3.Development Area Significant data**

| | |
|---|---|
| Project Location (Political) | Northern Georgia's Samegrelo-Upper Svaneti (Zemo Svaneti) Region |
| Political Subdivisions | Mestia District |
| Area Population | 14,248 |
| Nearest Town or City | Mestia |
| River Name | Mulkhura |
| Economic Activity in the Area | Primarily agriculture, logging and wood products for construction |
| Special Natural Resources | Timber, glaciers, mineral and building stone deposits. |
| Special Cultural Resources | Churches, monasteries, Svan defensive towers, hot and mineral springs, etc. |
| Critical Environmental Receptors | Svaneti Planned Protected Area |

**Project area social characteristics**

The Mulkhura Project area is located in Mestia Municipality, which is part of the Samegrelo-Upper Svaneti Region Administrative Unit. The Mestia Municipality occupies the upper part of the Enguri River watershed and is located between the elevations of 800 m and 5,070 m above sea level. Mestia Municipality occupies a total area of 3,044.5 km2. The population for the whole district is about 14,248, giving a population density of 4.7 people/km2. Of the residents, 99.4% are Georgians.

The economy is mainly based on subsistence agriculture. Animal husbandry, grain and hay crop production, vegetable (mainly potatos) production, and forestry are developed in the region. The Mestia District is well-known for its mineral resources.
Mestia is one of the most popular tourist spots in the country, due to rich natural, cultural and historical assets. The Upper Svaneti area is listed among the UNESCO World Heritage Sites. Planned Protected Areas within the Mestia Municipality occupy 46,122 ha. Extensive tourist developments are under construction or planned for the area. These include a world-class skiing and winter sports destination resort.
The Mulkhura Project area extends westward from central Mestia, the administrative center of Upper Svaneti, to Lakhushdi Village. Mestia's population is 2,600 people (population census, 2002). The surroundings of Mestia are abundant in mineral springs. The town is known for its medieval cultural and historic monuments, including the distinctive Svan defensive towers. The town is

experiencing extensive development. The town centre and communal infrastructure (water, sewage, energy) are being rehabilitated, and many privately owned properties are being upgraded.
Lakhushdi is 11 km away from Mestia and it is within the Latali community of settlements. It has a population of 61 people. Lakhushdi is rich in cultural and historical monuments. Traces of up to 76 medieval churches are found in the village.

**Project area environmental characteristics**

***Flora:*** The Enguri River watershed in the Upper Svaneti is rich in biological resources. Plants are distributed according to the vertical zoning here. Mixed mountain forests and alpine meadows are common to the area. Sub-nival and nival belts (snow-influenced vegetation belts) range between 3,200 and 3,800 meters above sea level. The Enguri River watershed is rich in relict and endemic species. Svaneti flora counts for 1,100 species of vascular plants, 264 of which are endemic.

Mountain forests (1,200-1,900 masl) distributed on the Southern Caucasus and Svaneti ranges along Nenskra, Nakra, Mestiatchala, Mulkhura and other rivers usually have broad-leaf species dominating at the lower altitudes and conifers leading at the upper elevations. Mixed mountain forests are distributed within the project area along the Mulkhura River. High mountain oak, beech, hornbeam, alder, and lime-tree are prominent in deciduous forests; while pine and fir trees with an irregular distribution of spruce are dominant among conifers.

***Fauna:*** The Enguri River watershed area shelters up to 55 species of mammals, 152 of birds, 7 reptile, 3 amphibian and 35 fish species. Brown bear, wolf, jackal, fox, European wild cat, pine marten, roe deer, common otter, and mink are found in mountain forests; while Caucasian shrew, long-clawed vole, and West and East Caucasian tur (goat-antelopes) inhabit subalpine and alpine zones of Svaneti. A diverse population of falcons, eagles, hawks, woodpeckers, owls, pigeons, passerines, and near-passerines is distributed within the Enguri watershed. Common trout, Crimea barbel, Colchic nase, chub, minnow, and gudgeon are among fishes dwelling in the Enguri river and its tributaries.

Some of the resident species are among the "red-list" species of Georgia, including West Caucasian tur (Endangered), East Caucasian tur (Vulnerable), Brown bear (Endangered), Black Grouse (Vulnerable), common trout (Vulnerable), etc.*(Source: Upper Svaneti Protected Areas Management Plan, 2008)*

**Transmission**

A new 110 kV transmission line, about 8 kilometers long for the option A and a new 35 kV transmission line, about 2 km long for the option B, will have to be built to carry the power from the Mulkhura substation to the existing, or a future, Mestia area SS.

## Access to the area

A new airport recently opened in Mestia, and daily prop-jet flights are available from Tbilisi. Highway access to the upper Enguri Basin is much improved over the situation only a year ago. The road from Zugdidi (the Regional Capital) to Mestia has been completely rebuilt and repaved, with new drainage, short tunnels to bypass some dangerous curves, guide rails along steep drop-offs, etc. It is now possible to drive from Tbilisi to Mestia in less than 7 hours. This road is expected to be kept open throughout the winter to accommodate winter sports enthusiasts as well as local residents.

The main roads beyond Mestia and the local roads are unpaved, without exception. They are in fairly good condition and are regularly maintained, but are often passable only by trucks, buses, and 4-wheel-drive vehicles with adequate ground clearance. Some are closed during the winter and all are subject to temporary closure due to snow, avalanches, rockfalls, landslides, floods, etc. Not all minor stream crossings have bridges.

The Roads Department in the Ministry of Regional Development and Infrastructure has recently announced a GEL 50 million project to rehabilitate the main road between Mestia and Ushguli. Tendering for construction is expected to begin soon, and work is expected to proceed at an accelerated pace.

Access to the proposed diversion structure for Mulkhura is very good. It is located just outside the center of Mestia. The only issue will be the steepness of the river gorge walls. The power plant site is low in the valley below Lakhushdi, only about one kilometer from the main road into Mestia. Existing side roads to the power plant site will have to be upgraded, and a new bridge across the Mulkhura River will probably be necessary.

*The Mulkhura River and the access road along the river .Image from Google Earth*

## BASELINE CONDITION

### Data availability

***Maps.*** Soviet-era topographic maps are available for the entire study area at 1:200,000; 1:100,000; and 1:50,000. Most of the area is covered by 1:25,000 topography that has been available to HIPP at no cost. The entire area is probably covered at this scale, but funds are not available to purchase scanned copies of the sheets missing from our source's files. This Soviet mapping has been used to prepare the Project Arrangement Drawing, Figure 1 (A and B), and the River Profile, Figure 2.

Geologic mapping is available for the entire area at scales of 1:50,000 and 1:25,000. Information from these maps has been used to prepare the Project Geologic Map, Figure 3 (A and B).

***Aerial and Satellite Imagery***. Part of the area is covered by Google Earth imagery that shows useful detail, but the Google service has only low-resolution satellite imagery for most of the area. The local firm GeoGraphic has high-resolution, aerial color imagery, taken in 2010, for the entire area but funds are not available to purchase the material at this time.

## HYDROLOGY AND WATER RESOURCES

### Table 3. Hydrology Significant Data

| | |
|---|---|
| Method of analysis | Monthly |
| Drainage area at gauges (Mestia and Mulkhura at mineral spring) | 144+197=341km$^2$ |
| Total drainage area for the Mulkhura HPP | 382.8 km$^2$ |
| Adjustment factor | 1.123 |
| Maximum plant discharge | 50.0 m$^3$/s |
| Minimum plant discharge | As low as 2.6 m$^3$/s |
| Flood flows | Average Annual Flood 150 m$^3$/s* |
| Highest recorded flow (Mestia and Mulkhura at mineral spring) | 351 m$^3$/s; 94 m$^3$/s |
| Calculated 100 year flood | 439 m$^3$/s* |
| Records available | Mean monthly flows of the Mulkhura River at Mestia gauging station for 36 years, from publications of the Hydromet. Daily records exist, but could not be obtained for this study. And mean monthly flows of the Mulkhura mineral spring gauging station for 19 years. |
| Recommended additional data collection and study recommendations for feasibility and design | Re-establish a stream flow gauging stations at the former location of the Mestia and Mulkhura mineral spring gauging sites. These stream gauge locations would also be used for monitoring of suspended and bed load sediments, water quality parameters, water temperature, fish, etc. |

*These flood flows are based on a simple drainage area ratio adjustment of the Mestia and Mulkhura spring gauge data. They are probably slight underestimations of flood flows at the diversion. That is due to the smaller drainage basins and steeper tributary areas, which results in shorter times of concentration.

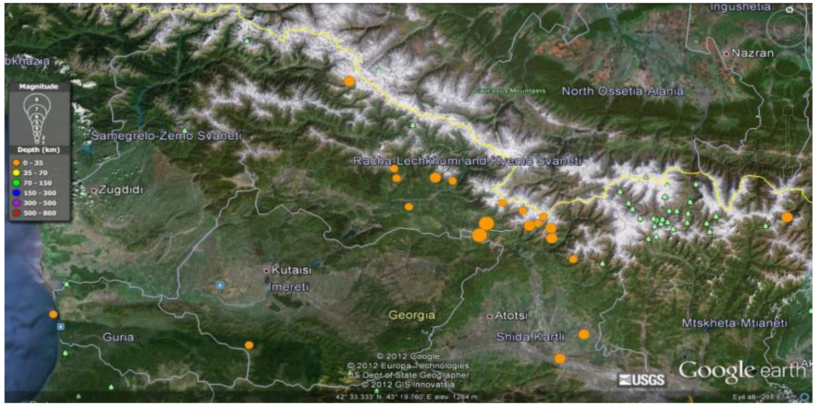
## Flooding and flooding risk

1. Flooding occurs frequently in the project watershed and in the project vicinity. Steep slopes, deep gorges, significant areas of exposed rock and impervious surfaces, snowmelt runoff enhanced by warm temperatures and intense precipitation all contribute to major flooding risk for the project and the local environment.
2. 36 years for Mestia and 19 years for Mulkhura of peak flood flow data are available for the stream-flow gauges. These data points were analyzed using the U.S. Army Corps of Engineers Hydrologic Engineering Center - Statistical Software Package (HEC-SSP) computer program, Version 2.0. See: http://www.hec.usace.army.mil/
3. A Log-Pearson III analysis was prepared, following the procedures in United States Water Resources Council Bulletin 17B, *Guidelines for Determining Flood Flow Frequency:* http://water.usgs.gov/osw/bulletin17b/bulletin_17B.html. The results are shown on the following plot:

## Geology

It was not possible to obtain historic sediment data for the Mulkhura River during this assessment study, but it is believed that such data were collected by Tbilisi HydroProject, which installed and operated the gauge during the 1950s and 1960s. Every attempt to obtain that data and acquire new sediment data should be made during feasibility studies. Suspended solids, bed load, grain size distribution, and mineralogical data are needed for design of the intake structure and to prepare turbine specifications that account for the erosive properties of particles that are not removed.

## Seismology




The project site is within a very active seismic zone. The geology of the project area is within the Fold System of the Greater Caucasus (Gagra-Djava Zone) as defined by I. Gamkrelidze (2000). As a result of its location on the boundary of colliding tectonic plates, according to the current Georgian seismic zoning classification the project is in hazardous zone 9 (the zone with greatest hazard). The design criteria for earthquake loads and resistance of structures must be defined in accordance with applicable standards and regulations.

The following Google Earth image shows the locations of earthquakes with a Magnitude of 5 and above, within 150 km of Mestia, taken from the United States Geological Survey databases of historic major earthquakes and of recent earthquakes. Earthquake activity has been more frequent to the east of the Upper Svaneti projects, though the risk of large earthquakes is similar.

## Hydrology

Available flow data Monthly stream flow data were used for this study. Daily data exists, but was not available to us. The following table lists the gauging station data that is believed to be available, and the current status of data collection:

*Table 4: Stream Gauges in the Upper Enguri Watershed*

| River | Location | Drainage Area, $km^2$ | Period of Record | Gauge Owner | Comments |
|---|---|---|---|---|---|
| Enguri | Ipari | 362 | 1967-1980 + ?? | | have monthly |
| Enguri | Latali | 975 | 1935-1938; 1955-1965++ | | have monthly |
| Enguri | Lakhamula | 1,410 | 1933-1942 | | short record |
| Enguri | Tobari Dam Site | 1462 | 1933-1978 | HydroProject Institute | no information |
| Enguri | Dizi | 1,760?? 1,620?? | 1932-1942; 1956-??; Khudoni FS got 1980-1989 | HydroMet | Have daily 1980-1989. Different areas reported. |
| Mulkhura | Cholashi | 186 | 1931-1932 | | very short record |
| Mulkhura | At mineral spring (Mestia) | 197 | 1962-1980++ | | have monthly |
| Mulkhura | Latali | 420 | 1932-1938 or 1933-1937? | | very short record |
| Mestiatchala | Mestia | 144 | 1939, 1940, 1942, 1943; 1946-1980++ | HydroMet | have daily flows to 1975, monthly to 1980 |
| Dolra | Becho | 146 | 1930-1933; 1956-1965++ | HydroProject Institute | very limited daily data received, monthly used |
| Khumpreri | near mouth | 160 | 1956-1965++ | HydroProject Institute | very limited daily data received, monthly used |

*Note: data from the shaded station are being used in this study.*

Drainage areas for the sub-basins have been computed using a digital terrain model of the upper Enguri River basin, developed from Soviet topography. These numbers have been supplemented and checked using areas measured from Soviet-era topographic maps using AutoCAD.

## SANITARY FLOWS

Georgian regulations require a part of the total flow in a stream to remain in that stream when water is diverted for hydroelectric power generation, irrigation, water supply, or other use. This bypass flow is often referred to as a “sanitary” flow, since a major purpose of the rule is to ensure that human and other waste products entering the stream bypass reach are diluted. In practice, sanitary flow is set as a 10 percent of the mean annual flow for the majority of studies in Georgia.

Modern hydroelectric practice considers biological habitat needs (and, sometimes, aesthetic and recreational concerns) when determining bypass flow. In-stream flow requirements to maintain healthy conditions for fish and other inhabitants are generally higher than the sanitary flows. They must generally be determined by environmental studies conducted during the feasibility or design stages of project development. In this study, assumed levels of bypass flow that vary from month to month have been adopted to estimate the flow actually available for the power generation. During low flow season sanitary flow is set as a 10% of the mean monthly flow, while for the rest of the period sanitary flow could be calculated as a 10% of the mean annual flow, data are shown in table 6. In fact, sanitary flow would be higher between the intake structure and the powerhouse due to the added inflow from the tributaries. However, it is recommended to have further detailed study of the bypass flow during the Feasibility Study.

## HYDROPOWER PROJECT DESCRIPTION

### General

The Mulkhura HPP development is expected to include a diversion weir across the Mulkhura River, intake structure, pressure tunnel, balance tank, penstock and surface powerhouse. A substation will be located near the plant. A 110 kV transmission line for the option A and 35 kV for the option B will connect Mulkhura SS to existing or future Mestia SS.

A tailrace of about 30-40 m open canal will convey water from the powerhouse to the Mulkhura River.

The power plant may be called on to work in island mode as well as in synchronization with the national power grid, allowing both direct and grid-connected supplies to consumers. To allow continuous operation of the Mulkhura plant, sufficient auxiliary backup power (probably a diesel generator) will be provided to allow black-starts when this plant is isolated from the national transmission network (island mode).

### Diversion facilities

The diversion for the run-of-river Mulkhura HPP will be located on the Mulkhura River. It will include a concrete overflow spillway section and a large sluice controlled by a radial gate. The low-level intake will be located on the left side of the river bank. The flow from the intake will enter a pressure tunnel. It will be important to design the diversion facilities so that an ice cover will develop over the entire pond during the winter. That will minimize the likelihood of problems with frazil ice clogging the waterways.

### Water conductors

The main water conductor will be a pressure tunnel from the intake structure to the proposed powerhouse. It may be excavated using drill and blast methods or a tunnel boring machine, and the finished tunnel cross-section will depend on the method selected. The alignment shown on the project arrangement drawing has been kept relatively close to the mountain slope, so intermediate adits can be drilled for access, ventilation, and muck removal if a contractor so chooses.
Based on the limited information available from existing geologic mapping and from field visits to the project location, it appears that most of the tunnel length can be supported during construction and long-term operation using rock bolts, steel mesh, and shotcrete.
2x150 m, is proposed to carry the flow from the pressure tank to the powerhouse below.

### Power plant

The powerhouse is expected to be a surface structure located along the Mulkhura River.
This installation will result in a maximum electric power output, at the high-voltage transformer terminals; data are shown in the following tables:

**Table 5: Mulkhura HPP Power and Energy Calculations**

| **Mulkhura HPP** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Calculations for Average Monthly Flows** | | | | | | | | | | | | |
| Mestiatchala riv. Streamflow gauge Mestia F=144 km$^2$ 1939,1940,1942,1943,1946-80 | | | | | | | | | | | | |
| **I** | **II** | **III** | **IV** | **V** | **VI** | **VII** | **VIII** | **IX** | **X** | **XI** | **XII** | **Average** |
| 2.60 | 2.71 | 2.83 | 6.18 | 14.00 | 25.10 | 36.40 | 28.20 | 25.10 | 10.90 | 7.17 | 5.25 | 13.87 |
| Mulkhura riv. at mineral spring F=197 km$^2$ 1962-80 | | | | | | | | | | | | |
| 2.53 | 2.47 | 2.79 | 4.62 | 10.70 | 22.40 | 36.90 | 34.40 | 17.10 | 7.37 | 3.96 | 2.97 | 12.35 |
| **Sum total** | | | | | | | | | | | | |
| 5.13 | 5.18 | 5.62 | 10.80 | 24.70 | 47.50 | 73.30 | 62.60 | 42.20 | 18.27 | 11.13 | 8.22 | 26.22 |
| Mulkhura riv. - ▼1370 F=382.83 km$^2$ K=382.83/(144+197)=1.123 | | | | | | | | | | | | |
| **5.76** | **5.82** | **6.31** | **12.13** | **27.74** | **53.34** | **82.32** | **70.30** | **47.39** | **20.52** | **12.50** | **9.23** | **29.45** |

| Mulkhura HPP | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydropower Calculations for Average Monthly Flows | | | | | | | | | | | | | $Q_{HPP}$= | 50 | $m^3/sec$ | |
| **Months** | Mean Monthly River flow $Q_{riv}$, $m^3/sec$ | Percent of mean monthly flow, % | Bypassed Flow Q, $m^3/sec$ | Extra Flow Q, $m^3/sec$ | HPP Flow $Q_{HPP}$, $m^3/sec$ | Diversion water level elevation ▼ upstream m | Tailwater elevation, ▼ downstream m | Gross head $H_{gross}$, m | Total head loss Sh, m | Net head, $H_{net}$, m | Turbine efficiency $h_t$, % | Turbine total capacity $N_t$, kW. | Generator efficiency $h_g$, % | Unit capacity $N_u$, kW. | Number of hours per month T, h. | Generated Energy, GWh. |
| **I** | **5.76** | **10** | 0.58 | _ | **5.18** | 1,385 | 1,310 | 75.00 | 0.06 | 74.94 | 0.90 | 3,427 | 0.96 | 3,290 | 744 | 2.448 |
| **II** | **5.82** | **10** | 0.58 | _ | **5.24** | 1,385 | 1,310 | 75.00 | 0.06 | 74.94 | 0.90 | 3,460 | 0.96 | 3,322 | 672 | 2.232 |
| **III** | **6.31** | **10** | 0.63 | _ | **5.68** | 1,385 | 1,310 | 75.00 | 0.07 | 74.93 | 0.90 | 3,754 | 0.96 | 3,604 | 744 | 2.681 |
| **IV** | **12.13** | **10** | 1.21 | _ | **10.92** | 1,385 | 1,310 | 75.00 | 0.27 | 74.73 | 0.90 | 7,195 | 0.96 | 6,907 | 720 | 4.973 |
| **V** | **27.74** | **10** | 2.77 | _ | **24.96** | 1,385 | 1,310 | 75.00 | 1.41 | 73.59 | 0.90 | 16,204 | 0.96 | 15,555 | 744 | 11.573 |
| **VI** | **53.34** | **6** | 2.94 | 0.40 | **50.00** | 1,385 | 1,310 | 75.00 | 5.65 | 69.35 | 0.90 | 30,582 | 0.96 | 29,359 | 720 | 21.138 |
| **VII** | **82.32** | **39** | 2.94 | 29.38 | **50.00** | 1,385 | 1,310 | 75.00 | 5.65 | 69.35 | 0.90 | 30,582 | 0.96 | 29,359 | 744 | 21.843 |
| **VIII** | **70.30** | **29** | 2.94 | 17.36 | **50.00** | 1,385 | 1,310 | 75.00 | 5.65 | 69.35 | 0.90 | 30,582 | 0.96 | 29,359 | 744 | 21.843 |
| **IX** | **47.39** | **6** | 2.94 | _ | **44.45** | 1,385 | 1,310 | 75.00 | 4.47 | 70.53 | 0.90 | 27,653 | 0.96 | 26,547 | 720 | 19.114 |
| **X** | **20.52** | **10** | 2.05 | _ | **18.47** | 1,385 | 1,310 | 75.00 | 0.77 | 74.23 | 0.90 | 12,089 | 0.96 | 11,606 | 744 | 8.635 |
| **XI** | **12.50** | **10** | 1.25 | _ | **11.25** | 1,385 | 1,310 | 75.00 | 0.29 | 74.71 | 0.90 | 7,413 | 0.96 | 7,116 | 720 | 5.124 |
| **XII** | **9.23** | **10** | 0.92 | _ | **8.31** | 1,385 | 1,310 | 75.00 | 0.16 | 74.84 | 0.90 | 5,484 | 0.96 | 5,265 | 744 | 3.917 |
| Gross average annual generation excluding losses | | | | | | | | | | | | | | **125.521** | GWh | |
| Estimated energy losses from outages, substation losses 5% | | | | | | | | | | | | | | **6.276** | GWh | |
| Average annual energy for sale | | | | | | | | | | | | | | **119.245** | GWh | |
| HPP operation duration per year | | | | | | | | | | | | | | **4,275** | h | |
| Capacity usage ratio/efficiency (plant factor) | | | | | | | | | | | | | | **0.49** | | |

## ENVIRONMENT AND SOCIAL STUDIES

Risks to an environmental receptor from the activities (development and operation of the Mulkhura HPP) are expected to be low, based on information that is available at this time.

One impact category that will be very important for most of the hydro project developments in the upper Enguri River basin is the protection and preservation of historic and cultural monuments and artifacts.

The area also includes many other un-listed resources. In the specific case of the Mulkhura HPP, there are no listed or known cultural or archeological sites within or near the development area. However, during construction period unknown archeological sites could be revealed due to the cultural and archeological diversity of the region.

From an affected natural environmental perspective the Mulkhura HPP can be developed so that the project overall minimizes its construction and operations impacts on the local and watershed environment.

## PROJECT COST ESTIMATE

The estimated cost of the Mulkhura HPP is US$ 38.4 million, or about US$ 1,305/kW of installed capacity, including VAT and a 25% contingency. The project is expected to have a 1-year pre-construction period and 3-4-year construction period. The critical path for the project may be controlled by the tunnel construction or by the procurement, manufacture, delivery and installation of major mechanical and electrical components.

### Table 6. Mulkhura HPP Estimated Capital Expenditure

| Mulkhura B HPP CAPEX | | | | |
|---|---|---|---|---|
| | **Units** | **Amt** | **Unit Cost** | **Total US$** |
| **Land purchase** | ha | 15 | $12,000 | $180,000 |
| **Preparatory & infrastructure works** | LS | | | $650,000 |
| **New Bridges above Mulkhura Riv.** | m | 40-50 | | $620,000 |
| **New access road (8 m wide gravel)** | m | 1,000 | $130 | $130,000 |
| **Improvement of existing access road** | m | 3,000 | $20 | $60,000 |
| **Stream diversion and cofferdams** | LS | | | $650,000 |
| **Main Dam & Intake Structure** | LS | | | $2,400,000 |
| **Tunnel including rock bolts & shotcrete** | m | 3,000 | $2,300 | $6,900,000 |
| **Adits** | m | 70 | $1,350 | $94,500 |
| **Balance Tank** | LS | | | $650,000 |
| **Steel Penstock (D=3.6m)** | m | 300 | $2,400 | $720,000 |

| | | | | |
|---|---|---|---|---|
| **Above ground power house and Tailrace canal** | LS | | | $1,650,000 |
| **Turbines, Generators, Governors, Auxiliaries, etc *** | MW | 29.4 | $200,000 | $5,880,000 |
| **Transformers and Switchyard equipment *** | MW | 29.4 | $72,000 | $2,116,800 |
| **Grid connection transmission line @ 35 kV** | km | 2 | $70,000 | $140,000 |
| **Subtotal of Schedule Items** | | | | **$22,841,300** |
| **Geology (investigation field, lab and office) @ 1.5%** | LS | | | $342,620 |
| **Feasibility study @ 1%** | LS | | | $228,413 |
| **EIA @ 1%** | LS | | | $228,413 |
| **EPCM @ 14%** | LS | | | $3,197,782 |
| **Contingencies (Assumptions Variable) @ 25%** | LS | | | $5,710,325 |
| **Subtotal** | | | | **$32,548,853** |
| **VAT 18%** | | | | **$5,826,393** |
| **Total** | | | | **$38,375,246** |
| **MW Capacity** | **29.40** | **CAPEX/kW** | | **$1,305,280** |

## Enguri 6 HPP

Enguri 6 SHPP is run—off the river scheme power plant.

### Project Description

The Enguri 6 HPP site is located along the relatively inaccessible reach of the Enguri River between the Ipari and Latali communities. The Upper Enguri River watershed lies between the south slope of the Greater Caucasus Mountain Range and the north slopes of the Svaneti Mountain Range. The Enguri River in this area has a moderate slope, providing a good opportunity to develop a project that is expected to be financially attractive.

The Enguri 6 Hydropower Plant (HPP) site is located on a left-bank of the Enguri River, located about 10 km downstream from the developed area of Mestia district of northern Georgia's Samegrelo-Upper (Zemo) Svaneti Region. The Enguri River watershed lies on the south slope of the Greater Caucasus Mountain Range. The river is steep, providing a very good opportunity to develop a project that is expected to be quite financially attractive.

The geologic conditions in the upper Enguri Basin are extremely variable. This area is in the center of the folds and uplifts that create the Greater Caucasus Mountain Range. Extensive faulting and earthquake probability is fairly high. Rock ranges from very strong and massive granite deposits, through metamorphic rock zones of all types, to poorly cemented conglomerates and very

deep glacial terrace and alluvial deposits. Detailed geologic studies and careful orientation and placement of structures will be required to develop a successful project.
The river flows in Upper Svaneti are very seasonal. Discharges are low during winter months when most precipitation falls as snow, and are high during spring and summer when melt-water and rain runoff are combined. The variability is demonstrated in the following chart, which shows the seasonality of flow at gauging stations in the upper Enguri River basin:
The diversion point for Enguri 6 is on the Enguri River, about 9 km downstream of Bogreshi Village in Ipari, and about 7 km upstream from Lakhushdi. Moderate flows and head are available at this location, making an HPP of about 6.5 MW appear attractive.
No detail information on Enguri 6 HPP are available at this stage of the study

# 7.0 APPENDIX B: TARIFF CALCULATION

## Feasibility Indicators, Key Results & Key Info

Enguri VI

| KEY TECHNICAL DATA | |
|---|---|
| Construction Period | 4 Yr. |
| Plant Operational Life | 20 Yr. |
| Installed Capacity | 34.0 MW |
| Plant factor | 48% |
| Annual Working Hours | 4,214 h |
| Installed Cost - CAPEX per MWH ($ 000) | 1,423 |
| Electric & Mechanical Parts (Turn Key) | CH |

| Investment Terms & FEASIBILITY Indicators | Req Rate of Return | NPV $ 000 | IRR | Invstment $000 | % in Equity |
|---|---|---|---|---|---|
| Equity Holder #1 | 15% | 8,375 | 26.70% | 12,850 | 100% |
| Equity Holder #2 | | - | | - | |
| Total Project | | 15,198 | 14% | 48,376 | |

| Loan Terms & Indicators | |
|---|---|
| Loan Amount $ 000 | 35,525 |
| Grace Period | |
| Loan Duration (Incl Grace) | 20 Yrs |
| Loan Interest Rate | 10% |

| | |
|---|---|
| WACC | 10% |
| Min Debt Coverage Ratio is at Year 20 | 2.0 |

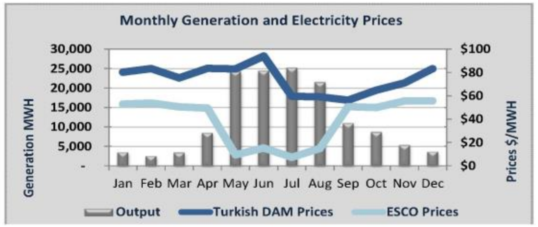
| Pick Year for showing KEY Financial Ratios - Year | 4 Y |
|---|---|
| GP Margin | 98.47% |
| EBIT (Op pr margin) | 66.57% |
| Net profit margin | 28.61% |
| ROCE | 12.08% |
| ROE | 12.12% |
| Debt Coverage Ratio | 2.2 |

| BREAK EVEN INDICES | |
|---|---|
| Energy Output _sufficient to cover Fixed Costs & Debt Service | 72,241 MWH |
| Plant Factor Sufficient to cover Annual Cash Outflow | 24% |
| Output Safety Margin | 50% |
| Nominal Payback Period (from Deployment) | 6 Yrs |

| CAPEX Fundindg Facilities | Leverage |
|---|---|
| Loan | 73% |
| Equity Holder #1 | 27% |
| Equity Holder #2 | |
| Total Debt to Equity Ratio | 73% : 27% |

| Key Operatinoal & CAPEX Indicators | Base Case Inputs | Escalation from Base Case | Current Inputs |
|---|---|---|---|
| Output | 143,267 MWH | | 143,267 MWH |
| Sales price (weigh. ave) base year | $ 71.34 | | $ 71.34 |
| GE Transmission tariff (base year) | $ 5.09 | | $ 5.09 |
| TR Transmission tariff (base year) | $ - | | $ - |
| Total CAPEX $ 000 | 48,376 | | 48,376 |

| CASH MANAGEMENT INDICES | Average | Op. Year 8 |
|---|---|---|
| Annual Fixed Costs (Excl Depr & Fin Cost) $ 000 | 919 | 762 |
| Annual Debt service (at full ds) $ 000 | 4,173 | 4,173 |
| Cash Appl to Shareholder $ 000 | 4,857 | 5,113 |
| Variable Cost/Per MWH | $ 0.85 | $ 0.85 |
| Contribution per CU (Price - Variable Cost) | $ 70 | $ 70 |




**COST PER MWH _ Term Used Among ELECTRICITY INDUSTRY EXPERTS _ translate this term to financiers means _ MINIMUM ACCEPTABLE PRICE FOR INVESTOR**

| | Average | During Debt Service / if DS is Less Than Project Life | After Debt Service |
|---|---|---|---|
| Acceptable weighted average sales price for investor | $ 53.38 | | |
| ARR (Annual Required Revenue) $ 000 | 7,609 | | |

| Choose Option of Terminal Value Calculation and set Appropriate Rates | | |
|---|---|---|
| Scrap Value _ % of Initail CAPEX | 15% | ◉ Scrap Value |
| Perpetuity of last Years FCF discounted at DF | 20% | ○ Perpetuity Method |

# Feasibility Indicators, Key Results & Key Info

Enguri 6 B

| KEY TECHNICAL DATA | |
|---|---|
| Construction Period | 4 Yr. |
| Plant Operational Life | 20 Yr. |
| Installed Capacity | 6.5 MW |
| Plant factor | 47.77% |
| Annual Working Hours | 4,185 h |
| Installed Cost - CAPEX per MWH ($ 000) | 2,027 |
| Electric & Mechanical Parts (Turn Key) | CH |

| Investment Terms & FEASIBILITY Indicators | | | | | |
|---|---|---|---|---|---|
| | Req Rate of Return | NPV $ 000 | IRR | Invstment $000 | % in Eequity |
| Equity Holder #1 | 15% | (347) | 12.83% | 3,510 | 100% |
| Equity Holder #2 | | - | | - | |
| Total Project | | (262) | 10% | 13,177 | |

| Loan Terms & Indicators | |
|---|---|
| Loan Amount $ 000 | 9,667 |
| Grace Period | |
| Loan Duration (Incl Grace) | 20 Yrs |
| Loan Interest Rate | 10% |

| | |
|---|---|
| WACC | 10% |
| Min Debt Coverage Ratio is at Year 20 | 1.4 |

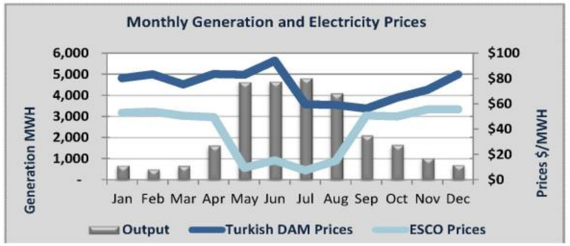
| Pick Year for showing KEY Financial Ratios - Year | 4 Y |
|---|---|
| GP Margin | 98.46% |
| EBIT (Op pr margin) | 53.09% |
| Net profit margin | 5.03% |
| ROCE | 8.00% |
| ROE | 2.58% |
| Debt Coverage Ratio | 1.5 |

| BREAK EVEN INDICES | |
|---|---|
| Energy Output _sufficient to cover Fixed Costs & Debt Service | 19,518 MWH |
| Plant Factor Sufficient to cover Annual Cash Outflow | 34% |
| Output Safety Margin | 72% |
| Nominal Payback Period (from Deployment) | 8 Yrs |

| CAPEX Fundindg Facilities | Leverage |
|---|---|
| Loan | 73% |
| Equity Holder #1 | 27% |
| Equity Holder #2 | |
| Total Debt to Equity Ratio | 73% : 27% |

| Key Operatinoal & CAPEX Indicators | Base Case Inputs | Escalation from Base Case | Current Inputs |
|---|---|---|---|
| Output | 27,200 MWH | | 27,200 MWH |
| Sales price (weigh. ave) base year | $ 71.34 | | $ 71.34 |
| GE Transmission tariff (base year) | $ 5.09 | | $ 5.09 |
| TR Transmission tariff (base year) | $ - | | $ - |
| Total CAPEX $ 000 | 13,177 | | 13,177 |

| CASH MANAGEMENT INDICES | Average | Op. Year 8 |
|---|---|---|
| Annual Fixed Costs (Excl Depr & Fin Cost) $ 000 | 240 | 197 |
| Annual Debt service (at full ds) $ 000 | 1,135 | 1,135 |
| Cash Appl to Shareholder $ 000 | 628 | 575 |
| Variable Cost/Per MWH | $ 0.85 | $ 0.85 |
| Contribution per CU (Price - Variable Cost) | $ 70 | $ 70 |




**COST PER MWH** _ Term Used Among ELECTRICITY INDUSTRY EXPERTS _ translate this term to financiers means _ MINIMUM ACCEPTABLE PRICE FOR INVESTOR

| | Average | During Debt Service / if DS is Less Than Project Life | After Debt Service |
|---|---|---|---|
| Acceptable weighted average sales price for investor | $ 75.11 | | |
| ARR (Annual Required Revenue) $ 000 | 2,033 | | |

| Choose Option of Terminal Value Calculation and set Appropriate Rates | | |
|---|---|---|
| Scrap Value _ % of Initail CAPEX | 15% | Scrap Value |
| Perpetuity of last Years FCF discounted at DF | 20% | Perpetuity Method |

# Feasibility Indicators, Key Results & Key Info

Mulkhura A

| KEY TECHNICAL DATA | |
|---|---|
| Construction Period | 3 Yr. |
| Plant Operational Life | 20 Yr. |
| Installed Capacity | 74.7 MW |
| Plant factor | 49% |
| Annual Working Hours | 4,306 h |
| Installed Cost - CAPEX per MWH ($ 000) | 990 |
| Electric & Mechanical Parts (Turn Key) | CH |

| Investment Terms & FEASIBILITY Indicators | | | | | |
|---|---|---|---|---|---|
| | Req Rate of Return | NPV $ 000 | IRR | Invstment $000 | % in Eequity |
| Equity Holder #1 | 15% | 31,953 | 36.26% | 20,733 | 100% |
| Equity Holder #2 | | - | | - | |
| Total Project | | 53,807 | 18% | 73,949 | |

| Loan Terms & Indicators | |
|---|---|
| Loan Amount $ 000 | 53,216 |
| Grace Period | |
| Loan Duration (Incl Grace) | 20 Yrs |
| Loan Interest Rate | 10% |

| | |
|---|---|
| WACC | 10% |
| Min Debt Coverage Ratio is at Year 20 | 2.9 |

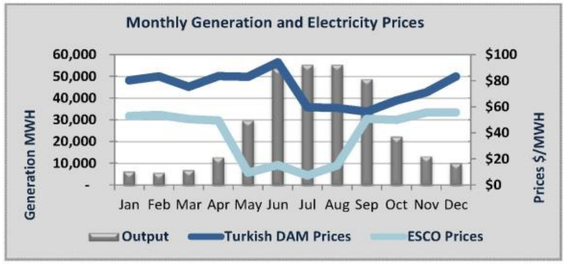
| Pick Year for showing KEY Financial Ratios - Year | 4 Y |
|---|---|
| GP Margin | 98.42% |
| EBIT (Op pr margin) | 76.82% |
| Net profit margin | 45.92% |
| ROCE | 15.99% |
| ROE | 16.71% |
| Debt Coverage Ratio | 3.3 |

| BREAK EVEN INDICES | |
|---|---|
| Energy Output _sufficient to cover Fixed Costs & Debt Service | 110,603 MWH |
| Plant Factor Sufficient to cover Annual Cash Outflow | 17% |
| Output Safety Margin | 34% |
| Nominal Payback Period (from Deployment) | 4 Yrs |

| CAPEX Fundindg Facilities | Leverage |
|---|---|
| Loan | 72% |
| Equity Holder #1 | 28% |
| Equity Holder #2 | |
| Total Debt to Equity Ratio | 72% : 28% |

| Key Operatinoal & CAPEX Indicators | Base Case Inputs | Escalation from Base Case | Current Inputs |
|---|---|---|---|
| Output | 321,672 MWH | | 321,672 MWH |
| Sales price (weigh. ave) base year | $ 68.71 | | $ 68.71 |
| GE Transmission tariff (base year) | $ 5.09 | | $ 5.09 |
| TR Transmission tariff (base year) | $ - | | $ - |
| Total CAPEX $ 000 | 73,949 | | 73,949 |

| CASH MANAGEMENT INDICES | Average | Op. Year 8 |
|---|---|---|
| Annual Fixed Costs (Excl Depr & Fin Cost) $ 000 | 1,254 | 1,016 |
| Annual Debt service (at full ds) $ 000 | 6,251 | 6,251 |
| Cash Appl to Shareholder $ 000 | 13,067 | 12,012 |
| Variable Cost/Per MWH | $ 0.85 | $ 0.85 |
| Contribution per CU (Price - Variable Cost) | $ 68 | $ 68 |




**COST PER MWH** _ Term Used Among ELECTRICITY INDUSTRY EXPERTS _ translate this term to financiers means _ MINIMUM ACCEPTABLE PRICE FOR INVESTOR

| | Average | During Debt Service / if DS is Less Than Project Life | After Debt Service |
|---|---|---|---|
| Acceptable weighted average sales price for investor | $ 37.35 | | |
| ARR (Annual Required Revenue) $ 000 | 11,954 | | |

| Choose Option of Terminal Value Calculation and set Appropriate Rates | | |
|---|---|---|
| Scrap Value _ % of Initail CAPEX | 15% | Scrap Value |
| Perpetuity of last Years FCF discounted at DF | 20% | Perpetuity Method |

## Feasibility Indicators, Key Results & Key Info

Mulkhura b

| KEY TECHNICAL DATA | |
|---|---|
| Construction Period | 4 Yr. |
| Plant Operational Life | 20 Yr. |
| Installed Capacity | 29.4 MW |
| Plant factor | 49% |
| Annual Working Hours | 4,269 h |
| Installed Cost - CAPEX per MWH ($ 000) | 1,129 |
| Electric & Mechanical Parts (Turn Key) | CH |

| Investment Terms & FEASIBILITY Indicators | | | | | |
|---|---|---|---|---|---|
| | Req Rate of Return | NPV $ 000 | IRR | Invstment $000 | % in Eequity |
| Equity Holder #1 | 15% | 11,030 | 36.09% | 8,819 | 100% |
| Equity Holder #2 | | - | | - | |
| Total Project | | 19,614 | 18% | 33,183 | |

| Loan Terms & Indicators | |
|---|---|
| Loan Amount $ 000 | 24,364 |
| Grace Period | |
| Loan Duration (Incl Grace) | 20 Yrs |
| Loan Interest Rate | 10% |

| | |
|---|---|
| WACC | 10% |
| Min Debt Coverage Ratio is at Year 20 | 2.5 |

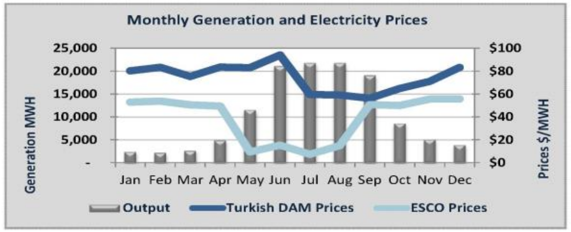
| Pick Year for showing KEY Financial Ratios - Year | 4 Y |
|---|---|
| GP Margin | 98.42% |
| EBIT (Op pr margin) | 73.31% |
| Net profit margin | 39.57% |
| ROCE | 14.50% |
| ROE | 15.38% |
| Debt Coverage Ratio | 2.8 |

| BREAK EVEN INDICES | |
|---|---|
| Energy Output _sufficient to cover Fixed Costs & Debt Service | 50,656 MWH |
| Plant Factor Sufficient to cover Annual Cash Outflow | 20% |
| Output Safety Margin | 40% |
| Nominal Payback Period (from Deployment) | 5 Yrs |

| CAPEX Fundindg Facilities | Leverage |
|---|---|
| Loan | 73% |
| Equity Holder #1 | 27% |
| Equity Holder #2 | |
| Total Debt to Equity Ratio | 73% : 27% |

| Key Operatinoal & CAPEX Indicators | Base Case Inputs | Escalation from Base Case | Current Inputs |
|---|---|---|---|
| Output | 125,521 MWH | | 125,521 MWH |
| Sales price (weigh. ave) base year | $ 68.70 | | $ 68.70 |
| GE Transmission tariff (base year) | $ 5.09 | | $ 5.09 |
| TR Transmission tariff (base year) | $ - | | $ - |
| Total CAPEX $ 000 | 33,183 | | 33,183 |

| CASH MANAGEMENT INDICES | Average | Op. Year 8 |
|---|---|---|
| Annual Fixed Costs (Excl Depr & Fin Cost) $ 000 | 575 | 468 |
| Annual Debt service (at full ds) $ 000 | 2,862 | 2,862 |
| Cash Appl to Shareholder $ 000 | 4,722 | 4,249 |
| Variable Cost/Per MWH | $ 0.85 | $ 0.85 |
| Contribution per CU (Price - Variable Cost) | $ 68 | $ 68 |




| COST PER MWH _ Term Used Among ELECTRICITY INDUSTRY EXPERTS _ translate this term to financiers means _ MINIMUM ACCEPTABLE PRICE FOR INVESTOR | | | |
|---|---|---|---|
| | Average | During Debt Service / if DS is Less Than Project Life | After Debt Service |
| Acceptable weighted average sales price for investor | $ 41.37 | | |
| ARR (Annual Required Revenue) $ 000 | 5,166 | | |

| Choose Option of Terminal Value Calculation and set Appropriate Rates | | |
|---|---|---|
| Scrap Value _ % of Initail CAPEX | 15% | ◉ Scrap Value |
| Perpetuity of last Years FCF discounted at DF | 20% | ○ Perpetuity Method |

## Feasibility Indicators, Key Results & Key Info

Pari A

| KEY TECHNICAL DATA | |
|---|---|
| Construction Period | 4 Yr. |
| Plant Operational Life | 20 Yr. |
| Installed Capacity | 100.0 MW |
| Plant factor | 28.54% |
| Annual Working Hours | 2,500 h |
| Installed Cost - CAPEX per MWH ($ 000) | 1,653 |
| Electric & Mechanical Parts (Turn Key) | CH |

| Investment Terms & FEASIBILITY Indicators | Req Rate of Return | NPV $ 000 | IRR | Invstment $000 | % in Equity |
|---|---|---|---|---|---|
| Equity Holder #1 | 15% | (20,820) | 2.41% | 45,000 | 100% |
| Equity Holder #2 | | - | | - | |
| Total Project | | (18,451) | 8% | 165,330 | |

| Loan Terms & Indicators | |
|---|---|
| Loan Amount $ 000 | 120,330 |
| Grace Period | |
| Loan Duration (Incl Grace) | 20 Yrs |
| Loan Interest Rate | 10% |

| | |
|---|---|
| WACC | 10% |
| Min Debt Coverage Ratio is at Year 1 | 1.1 |

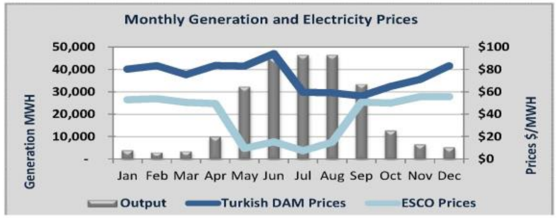
| Pick Year for showing KEY Financial Ratios - Year | 4 Y |
|---|---|
| GP Margin | 98.35% |
| EBIT (Op pr margin) | 39.08% |
| Net profit margin | -26.21% |
| ROCE | 4.75% |
| ROE | -18.27% |
| Debt Coverage Ratio | 1.1 |

| BREAK EVEN INDICES | |
|---|---|
| Energy Output _sufficient to cover Fixed Costs & Debt Service | 238,437 MWH |
| Plant Factor Sufficient to cover Annual Cash Outflow | 27% |
| Output Safety Margin | 95% |
| Nominal Payback Period (from Deployment) | |

| CAPEX Fundindg Facilities | Leverage |
|---|---|
| Loan | 73% |
| Equity Holder #1 | 27% |
| Equity Holder #2 | |
| Total Debt to Equity Ratio | 73% : 27% |

| Key Operatinoal & CAPEX Indicators | Base Case Inputs | Escalation from Base Case | Current Inputs |
|---|---|---|---|
| Output | 250,000 MWH | | 250,000 MWH |
| Sales price (weigh. ave) base year | $ 69.80 | | $ 69.80 |
| GE Transmission tariff (base year) | $ 5.09 | | $ 5.09 |
| TR Transmission tariff (base year) | $ - | | $ - |
| Total CAPEX $ 000 | 165,330 | | 165,330 |

| CASH MANAGEMENT INDICES | Average | Op. Year 8 |
|---|---|---|
| Annual Fixed Costs (Excl Depr & Fin Cost) $ 000 | 2,330 | 1,793 |
| Annual Debt service (at full ds) $ 000 | 14,134 | 14,134 |
| Cash Appl to Shareholder $ 000 | 2,698 | 1,249 |
| Variable Cost/Per MWH | $ 0.75 | $ 0.75 |
| Contribution per CU (Price - Variable Cost) | $ 69 | $ 69 |




**COST PER MWH** _ Term Used Among ELECTRICITY INDUSTRY EXPERTS _ translate this term to financiers means _ MINIMUM ACCEPTABLE PRICE FOR INVESTOR

| | Average | During Debt Service / if DS is Less Than Project Life | After Debt Service |
|---|---|---|---|
| Acceptable weighted average sales price for investor | $ 99.33 | | |
| ARR (Annual Required Revenue) $ 000 | 24,708 | | |

| Choose Option of Terminal Value Calculation and set Appropriate Rates | | |
|---|---|---|
| Scrap Value _ % of Initail CAPEX | 15% | ◉ Scrap Value |
| Perpetuity of last Years FCF discounted at DF | 20% | ○ Perpetuity Method |

# 8.0 APPENDIX C: CONSULTATION MEETING FOR CBA MODEL FOR THE ENGURI WATERSHED AREA

## Meeting Minutes

**TITLE:** Cost-Benefit Analysis Model Development for the Enguri Watershed Area - Consultation Meeting

**DATE:** August 12, 2014

**VENUE: USAID Office, Tbilisi**

**PRESENT:** Ministry of Environment and Natural Resources Protection of Georgia;
Ministry of Economy of Georgia
Ministry of Economy and Sustainable Development of Georgia
WWF Caucasus Office
REC Caucasus
CENN
Green Alternative
Green Movement of Georgia
Energy Efficiency Center
TBSC Consulting

**TOPICS OF DISCUSSION**:

- CBA Template Model

**Background:**

- CBA model for watershed-based hydropower development in the Enguri watershed area has been carried out by the working group made-up from five NGOs and TBSC Consulting. The Working Group has developed a template model, which was tested on the Enguri watershed area using available data. As a result, a framework was created which describes different stages and steps one should follow to carry out CBA.

**DISCUSSION:**

- Participants of the consultation meeting discussed the CBA Model. All the participants of the CBA consultations meeting agreed that CBA Template Model needs further development and improvement. There was disagreement between different participants related using VoLL in the equation for calculating the CBA. Representative of the Ministry of Economy and Sustainable Development supported the VoLL approach, while majority of NGOs opposed it. CBA Model developed under the HPEP project covered the watershed to capture cumulative impacts from the all of the HPPs planned within the watershed area. However, this approach was questioned by the WWF Caucasus representative suggesting to develop a CBA Model for each individual HPP project. Green Alternative had doubts concerning the costs presented in the Model and accuracy of their classification according to the TEEB framework. This clearly showed that experts on TEEB should be invited to support relevant stakeholders to properly classify all the costs from the ecosystem services. Representatives from the Ministry of Environment suggested additional focus on the values that are incurred from rehabilitation, mitigation and compensation measures. Additionally, CBA analysis should clearly define the parties responsible for those costs. Several attendees also thought that it is very important for CBA to properly analyse who gets the benefits and who bears the costs from the construction and operation of the planned HPPs.
- Overall, all the participants recognized that CBA Template Model development is very challenging and it was very important initiative from USAID. This exercise can be regarded as a good starting point for further development of the Model, which would create a good basis for mainstreaming CBA in the policy agenda.

**Conclusions and steps to follow:**

- Improve CBA Template Model;
- Further discuss VoLL approach and carry out Georgia-specific survey on VoLL (possibly by GNERC);
- Invite experts to raise awareness on TEEB framework among relevant stakeholders;
- Establishment of the process of data-collection by the Government of Georgia.

**PREPARED BY**: Ketevan Skhireli

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